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Innovative Technologies and its Applications in Higher Education - Agriculture

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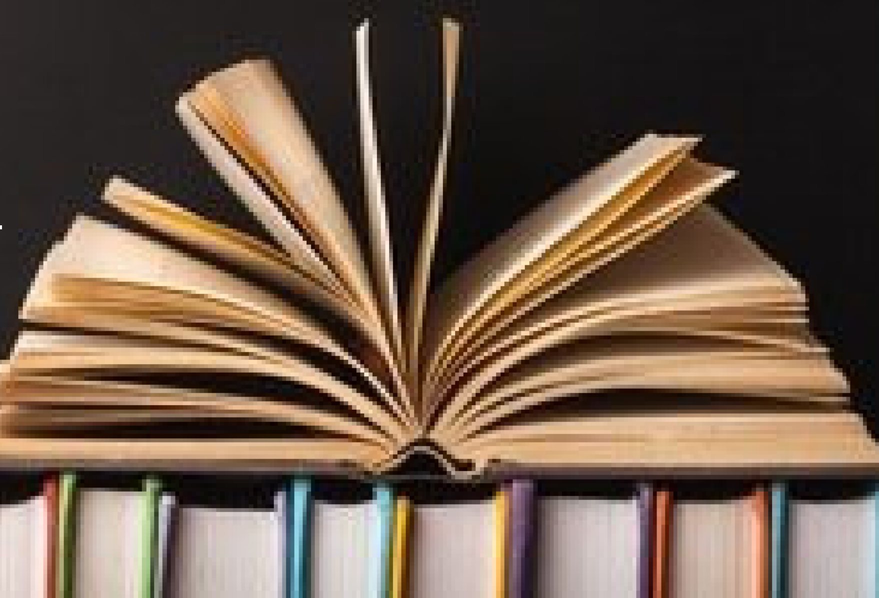

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ANNAMALAI UNIVERSITY

(State University-Accredited with 'A+' Grade by NAAC)
ANNAMALAINAGAR - 608 002, CHIDAMBARAM, TAMIL NADU, INDIA.

Prof. RM. KATHIRESAN, M.Sc.Ag., Ph.D., D.Sc
VICE-CHANCELLOR

Foreword

"Technology cannot replace the teacher but technology in the hands of a great teacher can be transformational"-- George Couros

In the age of technology advancement education is both a challenge as well as opportunity for innovation. Technological advancements pose both challenges as well as opportunities for teachers to enlarge the scope of education. Technology comes handy for educators to overcome certain barriers they have been facing all along.

Times of crisis have always motivated people to be inventive and innovative recently you all witnessed how during the times of Covid 19 a lot of innovations became possible with the help of technology, especially in the field of education. Perhaps, the process of education would have received a serious setback without the boon of modern technology. It was the time when we were compelled to move from traditional modes of education to online and electronic modes of education. It also helped us overcome the barriers of distance and time. Virtual classrooms and meetings plotforms became common that provided opportunities for both teachers and students to overcome the challenges posed during the Covid 19 lock down.

However, there is also a need to monitor the right use of technology efficiently both by the teacher and the learner. It is always good for those who are involved in the process of education to come together and take stock of things so that developments or possible. Exchanges lead to enlightenment and innovation. In this context the three-day international conference organised by the IQAC Annamalai University has provided the educators with a platform for scholarly exchange of ideas and experience. I also appreciate the efforts of the IQAC, Annamalai University to bring out a volume of the scholarly papers presented in the conference. I am sure that the proceedings of the conference will be of immense benefit to those who are involved in the process of education.

(RM. KATHIRESAN)

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PREFACE

Prof. S. Arivudainambi
Head, Dept.of Entomology
Director. IQAC
Annamalai University

I am extremely happy that the OQAC, Annamalai University, brings out the proceedings of the international conference on": Innovative Technologies and its Applications in Higher Education" The international conference was a grand success with more than 300 participants from across the globe and from diverse discipline.. The papers are segregated into five categories based on the subject domain and they are brought out in five volumes and I am sure that each volume will immensely benefit the academicians researchers and policy makers by not only enabling them coming to terms with the present scenario but also by facilitating them foresee the future.

At this juncture I on behalf of the IQAC, place on record my sincere gratitude to Prof. RM. Kathiresan, Vice Chancellor, for his relentless support. I also acknowledge the support extended by the officers of the university and faculty across disciplines I thank all the participants for their contribution of papers and cooperation.

S. Arivudainambi

A THREE DAY INTERNATIONAL CONFERENCE
ON
INNOVATIVE TECHNOLOGIES AND THEIR APPLICATIONS IN HIGHER EDUCATION - AGRICULTURE

17-19 October 2022

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CONTENTS

S.NO	TITLE	P.NO
1	STORABILITY OF POLYMER COATED COTTON SEEDS *S. Ambika V. Manonmani & S. Deepika*	1
2	PERFORMANCE OF GARLIC VARIETIES FOR YIELD PARAMETERS *P. M. Anand, R.Kamalkumaran, M.Velmurugan & G. Amuthaselvi*	7
3	ENFORCING GREEN REVOLUTION IN DRY-LANDS OF TAMIL NADU *Ananda Ganesa Raja B & Chand Asaf*	10
4	RESPONSE OF KURVAI RICE TO DIFFERENT PLANTING METHODS AND LEVELS OF NPK NUTRIENTS *P. Anandan, R. Seeraladevan, S. Natarajan, P.Stalin & K.P. Senthil Kumar*	13
5	COMBINING ABILITY AND NATURE OF GENE ACTION IN BHENDI (*Abelmoschus esculentus* (L.) Moench) *S. Kalaiselvan, S. Anuja, R. Sudhagar & N. Senthilkumar*	17
6	EFFECT OF PRUNING SEASON AND GROWTH RETARDANTS ON OFF-SEASON PRODUCTION OF ANNUAL MORINGA *R. Arulananth, S.Rameshkumar & M.Tamil Vanan*	25
7	EFFECT OF DIFFERENT WEED MANAGEMENT PRACTICES ON WEED DENSITY, YIELD AND ECONOMICS OF MAIZE (*Zea mays* L.) *E. Balaji, R.Raman & R.Krishnamoorthy*	27
8	STUDIES ON SEED LONGEIVITY OF ORGANIC PELLETED SEEDS FOR VIABILITY AND STORAGE IN BLACKGRAM (*Vigna mungo* (L.) Hepper) var. VBN 5 *M. Balasubramanian, S. Vennila, S. Suganthi & D. Sathyaraj*	32
9	EFFECT OF SEAWEED EXTRACT AND HUMIC ACID ON GROWTH OF CLUSTER BEAN (*Cyamopsis tetragonoloba* (L.) taub.) Var. PUSA NAVBHAR *D.. Bawya, A.Ramesh Kumar & P Madhanakumari*	38
10	ANALYZE OF WEED DENSITY AND WEED BIOMASS IN DIFFERENT RICE ESTABLISHMENT METHOD *M.S.Bhagavathi, G. Baradhan, S.M. Suresh Kumar & Jebarathnam Kuttibai*	42
11	EVALUATION OF ORGANIC EXTRACTS AGAINST DIAMOND BACK MOTH, *Plutella xylostella* (L.) ON CAULIFLOWER *S. K. Bhalkare, D. K. Shedge & D.B. Undirwade*	47

12	IMPACT OF PRESOWING SEED TREATMENT ON CROP GROWTH, SEED YIELD AND SEED QUALITY IN RICE *Kamaraj, A, S.Prasanth, P. Satheeshkumar, S. Suganthi & B.Sunilkumar*	54
13	EFFICACY OF BOTANICAL PLANT EXTRACTS AGAINST POD BORER COMPLEX IN BLACKGRAM *Chand Asaf & B.Ananda Ganesa Raja*	61
14	MEASURING THE IMPACT OF FOLIAGE ORNAMENTALS ON INDOOR AIR QUALITY IN DIGITAL PRINTING UNIT. *D.Dhanasekaran, CT.Sathappan & S .Rameshkumar*	67
15	SEXUAL DIMORPHISM IN AMARANTHUS LEAF WEBBER *Spoladea recurvalis* (Fabricius) (CRAMBIDAE: LEPIDOPTERA) *B Dhivya Bharathi*	75
16	IMPACTS OF BIOMASS BURNING ON ECOSYSTEM SERVICES *G K Dinesh, D K Sharma, M Sinduja, V Sathya, S Karthika S Kiruthiga & P.Sivasakthivelan*	77
17	SHELF-LIFE STUDY OF *Azospirillum* BIOINOCULANT WITH LIGNITE AS CARRIER MATERIAL ALONG WITH DIFFERENT ORGANIC AMENDMENTS *J.Divakaran, P.Sivasakthivelan, J.Jayachitra & S .Gomathi*	87
18	IMPACT OF CLIMATE CHANGE ON SOME AGRICULTURALLY IMPORTANT INSECT PESTS *Gangavarapu Nikhitha, Swarnali Bhattacharya, Mareedu Gopi Prasad, Subhajith Pal, G Manisankar & Kommu Naveen Yadav*	93
19	INFLUENCE OF DIFFERENT MICRONUTRIENTS ON YIELD PARAMETERS OF TURMERIC (Curcumalonga) *cv*. BSR 2 *M. Gayathiri & M. Prakash*	100
20	CHALLENGES AND STRATEGIES FOR INDIA'S SUSTAINABLE DAIRY FARMING *R. Gnanasekar, A. Varadharajan & S. Kothandaraman*	103
21	CURRENT STATUS OF ERICULTURE IN TAMIL NADU *R.K. Gokulakrishnaa & Selvamuthukumaran Thirunavukkarasu*	110
22	EFFICIENT RESOURCE CONSERVATION TECHNOLOGY AND FOLIAR FERTILIZATIONEFFECT ON GROWTH, YIELD ATTRIBUTES AND YIELD OF HYBRID MAIZE (Zea mays L.) *Gudapati Ashoka Chakravarthy, M. Thiruppathi, S. Kandasamy & K. Dhanasekaran*	112
23	BACTERIOCIN PRODUCTION BY A NEW ISOLATE OF *Pediococcus pentosaceous* UNDER DIFFERENT CULTURE CONDITIONS *J.Jayachitra, P.Sivasakthivelan, G.Kumaresan & E.Babu*	120
24	ANALYZE OF WEED DENSITY AND WEED BIOMASS IN DIFFERENT RICE ESTABLISHMENT METHOD *M.S.Bhagavathi , G. Baradhan, S.M. Suresh Kumar & T. Geetha Jebarathnam Kuttibai*	130

25	INNOVATIVENESS OF TURMERIC FARMERS IN PAPPIREDDIPATTI TALUK OF DHARMAPURI DISTRICT IN TAMIL NADU *R.Arunkumar, V.Kalirajan & D.Balu*	135
26	EFFECT OF FARM YARD MANURE AND BIOSTIMULANTS ON NUTRIENT UPTAKE AND POST HARVEST SOIL NUTRIENT STATUS IN *Jasminum grandiflorum* L. ROOTED CUTTINGS *S. Kamalakannan, G.Naveenkumar, R. Sudhagar, S. Kumar D. Elayaraja*	138
27	EFFECT OF STAKING AND INTERCROPPING ON PRODUCTIVITY OF GREATER YAM (*Dioscorea alata*) IN YAM BASED CROPPING SYSTEM *P.R. Kamalkumaran, M. Anand & M. Velmurugan*	143
28	FORAGING ACTIVITY OF INDIAN HONEYBEE, *Apis cerana indica* (HYMENOPTERA: APIDAE) DURING HONEY FLOW SEASON AT ANNAMALAI UNIVERSITY, CHIDAMBARAM, TAMIL NADU *M. Vikaash, R. Kanagarajan & K. Nishanthini*	148
29	EXOPOLYSACCHARIDE (EPS) MEDIATED INTERGENERIC COAGGREGATION AS A MECHANISM OF SALT TOLERANCE IN MAIZE *K.Kannan*	155
30	GENETIC VARIABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS FOR YIELD ATTRIBUTING CHARACTERS IN CHILLI *D.Kannan & K. Arulmani*	171
31	MANAGING WEEDS FOR SUSTAINABLE PRODUCTION OF DIRECT SEEDED RICE IN THE EMERGING CASES OF HERBICIDE RESISTANCE *Kommireddy Poojitha, K. N. Kalyana Murthy, M.T. Sanjay & G.N. Dhanapal*	180
32	RECENT ADVANCES IN WEED MANAGEMENT THROUGH HERBAL HERBICIDE *K. Naveen Yadav, B. Duary, & G. Nikhitha*	187
33	PRESENT SCENARIO AND FUTURISTIC APPLICATION OF ARTIFICIAL INTELLIGENCE IN ANIMAL HUSBANDRY – AN OVERVIEW *S.Kothandaraman, R.Gnanasekar &A.Varadharajan*	197
34	EFFECT OF LIQUID ORGANICS ON GERMINATION AND SEEDLING GROWTH OF MEXICAN ASTER (*Cosmos bipinnatus*) *S. Kumar, L. R. Arthi, Ajish Muraleedharan, S. Kamalakannan, R. Sudhagar & K. Sanjeev Kumar*	203
35	ENHANCING THE SHELF LIFE OF *Rhizobium* BIO INOCULANT BY DEVELOPMENT OF LIQUID FORMULATION *G. Kumaresan, N. Pandeeswari and J. Jayachitra*	207

36	IMPACT OF ORGANIC MANURES ON GROWTH AND YIELD PARAMETERS OF CAPSICUM (*Capsicum annuum* L.) UNDER PROTECTED CULTIVATION *P.Madhanakumari, S. Eswaramoorthy & V. M. Priyadarshini*	213
37	PATTERN OF CONSUMERISM AND ITS IMPACT OVER GREEN CONSUMERISM WITH REFERENCE TO BANGALORE CITY – AN EMPIRICAL OVERVIEW *Madhusudhan B. Joshi & Dr. S. Jambulingam*	217
38	STUDIES ON THE ROLE OF PGPR ON GROWTH AND YIELD ATTRIBUTES OF SUNFLOWER [*Helianthus annuus* L.] Var Co 1 *Mahalakshmi. S, M. Vijayapriya, P. Ramesh & J. Srimannarayanan*	224
39	STUDIES ON THE EFFECT OF FOOD ADDITIVES, PACKAGING MATERIALS AND STORAGE CONDITION ON TOTAL CARBOHYDRATE OF TAMARIND PULP (CV. PKM 1) DURING STORAGE *M. S. Marichamy & V. Kanthaswamy*	230
40	SCREENING OF OKRA HYBRIDS FOR YIELD, SHOOT AND FRUIT BORER, YELLOW VEIN MOSAIC VIRUS, OKRA ENATION LEAF CURL VIRUS AND POWDERY MILDEW DISEASE *V. Kanthaswamy, V. Subashri, M.S. Marichamy & E. Venkadeswaran*	238
41	TRANSFORMING INDIA'S HIGHER AGRICULTURAL EDUCATION SYSTEM - STRATEGIES FOR EFFECTIVE REFORMATION IN THE 21st CENTURY *J.Meenambiga, D.Lokeshwaran & S.Durairaj*	246
42	SESAME YIELD IMPROVEMENT TECHNIQUES *R.Ranjith, M.Meyyappan, M.Ganapathy & A.Ankayarkanni*	252
43	ASSESSMENT OF VULNERABILITY TO CLIMATE CHANGEON SUGARCANE PRODUCTION IN TAMILNADU *Mohanakrishnan Kuppan, Dr.A. Pouchepparadjou, Dr.N. Swaminatha,Mr.C.Aroutselvan & Dr.R.Sendhil*	258
44	EFFECT OF PLANT GROWTH REGULATORS ON ROOTING OF LEAF CUTTING IN GUAVA (*Pisidium guajava* L.) cv. ARKA KIRAN *S.Mullaimaran & M.Prakash*	264
45	EFFECT OF ORGANIC MANURES ON THE NUTRIENT UPTAKE OF *plectranthus vettiveroides* *C.Muruganandam & R.Dhesiyakumar*	270
46	EFFECT OF PGPR FROM SEWAGE ECOSYSTEM ENRICHED VERMICOMPOSTING ON GROWTH AND DEVELOPMENT OF CHILLI *K.Muthuselvam*	274

47	INFLUENCE OF FOLIAR APPLICATION OF NANO NUTRIENTS ON GROWTH OF CAPSICUM (*Capsicum annuum* L. var. grossum) *M. Nandhinidevi & J. Sam Ruban*	281
48	UTILIZATION OF PADDY EXPERT SYSTEM APP AND ITS EFFECTIVENESS ON FARMERS IN TIRUNELVELI DISTRICT OF TAMIL NADU *C K Nivedha & C Karthikeyan*	293
49	STUDIES ON THE EFFECT OF INCUBATION PERIOD AND THE AGE OF INOCULUM ON THE AMYLASE ENZYME PRODUCTION BY *Bacillus spp.* UNDER SOLID STATE FERMENTATION *N.Pandeeswari, G. Kumaresan & V.Prabudoss*	298
50	EFFECT OF INOCULATION OF SALT TOLERANT RHIZOBIA ON NODULE LEGHAEMOGLOBIN AND N CONTENT OF GROUNDNUT var. VRI-3 IN NORMAL AND SALINE SOIL *N. Pandeeswari*	304
51	EFFECT OF *G. diazotrophicus* AND *G. fasciculatum* WITH GRADED LEVELS OF N AND P FERTILIZERS ON THE GROWTH AND YIELD OF SUGARCANE UNDER FIELD CONDITION. *V. Prabudoss, D. Kanchana, G. Usharani, S. Gokulrajan & P. Shanmugaraja*	308
52	ECO-FRIENDLY WRAPPING MATERIALS FOR CONSUMER PREFERENCE OF CHINA ASTER FLOWERS *Pragnyashree Mishra*	316
53	GREEN TECHNOLOGIES AND GOOD AGRICULTURAL PRACTICES IN GOA *Ms. Pretty Louiza Pereira*	319
54	MICROGREENS – A COMPONENT OF SUSTAINABLE FOOD PRODUCTION *V. M. Priyadarshini & P. Madhana Kumari*	326
55	ARTIFICIAL INTELLIGENCE IN FARM EDUCATION, RESEARCH AND EXTENSION *T.Raj Pravin & V. Thirumal Kanna*	330
56	EFFECT OF ORGANIC INPUTS ON YIELD AND QUALITY OF SACRED BASIL (*Ocimum sanctum* L.) *R.Rajeswari., S.Sowndharya & P. Madhanakumari*	333
57	EFFECT OF ORGANIC AND CHEMICAL FERTILIZERON SEED YIELD, OIL CONTENT AND PROTEIN YIELD OF SUNFLOWER *S. Ramesh, S. Elankavi, P. Sudhakar and G. Baradhan*	339
58	DEMOGRAPHIC PROFILE OF DAIRY FARMERS IN DHARMAPURI DISTRICT *L.Murali Krishnan, R.John Christy & S.Vigil Anbiah*	346

59	IN VITRO DROUGHT SCREENING IN BLACKGRAM USING POLY ETHYLENE GLYCOL (PEG-6000) *T.Sabesan, Punitha.E, D Sathyaraj & K. Saravanan*	351
60	KNOWLEDGE LEVEL OF FARMERS ON COMMON PURSLANE (PORTULACAOLERACEAE) IN TAMIL NADU USING SIMPLE RANDOM SAMPLING METHOD *G.Sajiv & C. Muruganandam*	357
61	ENHANCEMENT OF SEED YIELD AND SEED QUALITY IN BLACKGRAM THROUGH SEED HARDENING *P. Satheeshkumar, K. Sarathi, K. Saravanan, A. Kamaraj & S. Suganthi*	362
62	STABILITY ANALYSIS IN FINGER MILLET [*Eleusine coracana* (L.) GAERTN] GENOTYPES USING LEWIS STABILITY FACTOR MODEL *D. Sathyaraj, T. Sabesan, K. Saravanan, L. Vengadeshkumar, S. Vennila & M. Balasubramanian*	369
63	STUDIES ON EFFECT OF PINCHING AND INTEGRATED NUTRIENTS ON CERTAIN GROWTH AND FLOWERING CHARACTERS OF CHRYSANTHEMUM (*Dendranthema grandiflora*) var. Poornima White *R. Sendhilnathan, V. Gowri sankari, R.Sureshkumar, M.Rajkumar & T.R. Barathkumar*	373
64	GRAFTING- EMERGING TECHNOLOGY IN BRINJAL (*Solanum melongena* L.) TO INCREASE THE YIELD AND QUALITY UNDER CHANGING ENVIRONMENT *Sherly. J & L. Pugalendhi*	380
65	ENVIRONMENTAL SAFETY OF PULSED ELECTRO MAGNETIC EXPOSURE SEED TREATMENTS AND ANALYSIS PHYSIOLOGICAL, BIOCHEMICAL ACTIVITY OF SEED STORABILITY IN BLACKGRAM *Dr. T. Shunmuga Vadivel & Dr. M. Sala*	386
66	SHELF-LIFE ENHANCEMENT OF *Azospirillum lipoferum* BIOINOCULANT IN LIQUID FORMULATION WITH DIFFERENT CHEMICAL AMENDMENTS *Sivasakthivelan. P., S. Gomathi, K.Arivukkarasu & J.Jayachitra*	395
67	EFFICACY STUDIES OF COST EFFECTIVE BIOFORMULATION OF CHITINOLYTIC BACTERIAL CONSORTIUM IN THE MANAGEMENT OF FOLIAR DISEASE INCIDENCE IN GROUNDNUT – AN INNOVATIVE APPROACH *S.Gomathi, P.Sivasakthivelan, J.Jayachitra & K.Arivukkarasu*	401
68	PROTECTED CULTIVATION TECHNOLOGIES IN VEGETABLE CROPS *T. Soniya, E. Arivazhagan & R. Kandasamy*	405

69	INFLUENCE OF ORGANIC MULCHES AND BIOSTIMULANTS ON VEGETATIVE PARAMETERS AND NUTRIENT UPTAKE OF TUBEROSE (*Polianthes tuberosa* L.) CV. PRAJWAL *R. Sudhagar, M. Arunkumar, S. Anuja,S. Kamalakannan & S. Kumar*	411
70	STUDIES ON CORRELATION AND PATH ANALYSIS IN RICE GENOTYPES FOR GRAIN YIELD UNDER INDUCED DROUGHT CONDITION *S.Suganthi, P. Satheeshkumar, A. Kamaraj, S. D.Vennila, R.Umamaheswari & Bhuvaneswari*	417
71	EFFECT OF MULCHING AND ORGANIC NUTRIENTS ON CERTAIN GROWTH AND PHYSIOLOGICAL CHARACTERS OF BOTTLE GOURD (*Lagenaria siceraria*) cv. PUNJAB KOMAL *V. Naveen, R. Sureshkumar,.R.Sendhilnathan, M.Rajkumar & T.R.Barathkumar*	423
72	EFFECT OF INM ON NUTRIENT UPTAKE AND AVAILABLE SOIL NUTRIENT STATUS IN SNAKE GOURD (*Trichosanthes cucumerina* L.) *R. Suriya, P. Madhanakumari & R. Rajeswari*	428
73	EFFECT OF PHOSPORUS LEVELS AND BIOFERTILIZERS ON NUTRIENT UPTAKE AND ECONOMICS OF IRRIGATED BLACKGRAM *M.Tamizhvendhan, S. Kandasamy & R. Raman*	434
74	EXPLORING HOST PLANT RESISTANCE AND DEVELOPING INTEGRATED NEMATODE MANAGEMENT STRATEGIES IN BRINJAL (*Solanum melongena* L.) *R. Umamaheswari, Pritee Singh, K. Hima Bindu & Tejaswini Prakash*	443
75	A ROUND-UP OF CLIMATE CHANGE AND FARM ANIMAL WELFARE IN COASTAL REGION OF TAMIL NADU *A. Varadharajan, R. Gnanasekar & S. Kothandaraman*	449
76	EFFECT OF COMPOSTS AND INDUSTRIAL BY-PRODUCTS ON SESAME YIELD AND POST HARVEST NUTRIENT STATUS *D. Venkatakrishnan, M. Manojkumar, D. Elayaraja, & S. Ravichandran*	454
77	STUDIES ON PER SE PERFORMANCE AND VARIABILITY FOR GRAIN NUTRITIONAL QUALITY IN POPULAR AND INDIGENOUS RICE (*Oryza sativa* L.) GENOTYPES OF TAMILNADU, INDIA *S. Vennila, J. Desika, R. Thirumalai, M. Balasubramanian, D. Sathyaraj & T. Thirumalaivasan*	462

78	EEFECT OF PLANT GROWTH PROMOTING RHIZOBACTERIA ON GROWTH AND YIELD OF TUBEROSE (*Polianthes tuberosa* L.) *M. Vijayapriya, S. Mahalakshmi, G. Madhumitha & V.Prabudoss*	465
79	INVASIVE WEEDS MANAGEMENT BY SUBMERGENCE TOLERANT RICE VARIETY AND HERBICIDES IN CAUVERY DELTA ZONE *S.Vishnudevi*	472

STORABILITY OF POLYMER COATED COTTON SEEDS

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Abstract

Seeds were coated with different polymers viz., Genius coat 171, Genius coat 172, Arcus, Myconate and Quick roots. The polymer coated seeds were stored in polyethylene bag of 700-gauge thickness and kept under ambient condition for nine months along with untreated control seeds and evalutead for the seedling quality parameters. The seeds coated with Quick roots polymer recorded higher germination of 88 per cent at the end on tenth month compared to untreated control seeds (77 per cent). Root and shoot length were also higher in seeds coated with Quick roots. The electrical conductivity (0.301dSm^{-1}) was low in the seeds coated with Quick roots with nil pathogen infection and insect incidence up to ten months of storage.

Key word: *Polymer, seed coating, cotton, Storage of seeds.*

Introduction

Due to climate change, temperature and Relative humidity gets changed oftenly. Storing of seeds in such environmental conditions may accelerate the ageing process. So, within a short period seed may lost their viability and vigor. Produced seeds may not be possible use within a year/season. So, it is need to be carrying over to the storage for marinating their viability and vigour for a certain period by proving controlled environmental conditions.

Cotton is the world's leading natural fibre crop. It is called as "King of Fibres" and "White of Gold". India is the second largest cotton producer in the world. But major problem in the growing of cotton crop is non availability of quality seeds. Cotton seed loses viability and vigour rapidly in storage as being the poor storer. So, seeds treatment should be practiced to protect their shelf life and to maintain their quality. Instead of treating the seeds with chemicals individually we can dissolve the fungicide, insecticide, micronutrients in polymer and it can be used for seed treatment as polymer coating. Polymer act as a binding material so it may cover the minor caracks if it presents on the seed there by reduces the fungal and insect invasion. Polymer coating reduces leaching of inhibitors from seed and restricts oxygen movement this leads to the reduction of respiration process of embryo thereby reducing the ageing process in seeds (Vanangamudi *et al*., 2003). Seed polymer coating is a cost-effective technique, less toxic and ecofriendly. Hence, an attempt was made to prolong the shelf life of the seeds through polymer coating techniques.

Materials and Methods

Akshay 65 F1 Bt cotton seeds were sent to the Integrated Coating Technology Pvt. Ltd., (INCOTEC), Ahmedabad, and Gujarat for coating through machine with different polymers *viz.*, Genius coat 171, Genius coat 172, Arcus, Myconate and Quick roots. The polymer coated seeds were stored in polyethylene bag of 700-gauge thickness and kept under ambient condition (28 ± 1^{o}C Temp and 70 ± 5 % RH) for ten months along with untreated control seeds. The seed samples drawn at monthly intervals and evaluated for various seed quality attributes

Seed senescence is an irreversible and inexorable process. However, the rate of seed deterioration could be slowed down either by proving controlled environmental conditions or by seed treatments with either chemicals or any other protectants. The germination of 97 per cent

recorded initially got reduced to 83 per cent at tenth month of storage (Table 1) (Plate 2). The seeds coated with Quick roots recorded a minimal decrease in germination and shown, 11 per cent increase over untreated control seed at tenth month of storage. The decline in germination over the period of storage might be due to depletion of food reserves coupled with decline in synthetic activity as reported by Ravichandran and Dharmalingam (1994) in paddy. Seedling length is the best indicator of seedling vigour. Similar trend of reduction as that of seed germination was noticed with respect to seedling length. On advancement of storage period, the seedlings length (root and shoot) was reduced. Initially the root length of 20.66 cm was recorded which got reduced to 19.48 cm at tenth month of storage (Table 2). The seeds coated with Quick roots recorded a minimal decrease in shoot length and shown 2 per cent increase over untreated control seed at tenth month of storage (Fig. 1). Initially the vigour index of 3925 was recorded which got significantly reduced to 3216 at tenth month of storage (Table 3).

The seeds coated with Quick roots recorded a minimal decrease in vigour index with 12 per cent increase over untreated control seed at tenth month of storage. Sujatha and Ramamoorthy (2009) reported that the green gram and red gram seeds coated with polymer recorded higher germination and seedling growth. The results are in confirmation with findings Renugadevi (2004) in cluster bean, Poonam Singh *et al.* (2004) in rice; Baig (2005) in soybean and Kunkur (2005) in cotton, Marimuthu (2007) in rice and Suresh Vegulla (2008) in maize. Giang and Gowda (2007) reported that the hybrid rice seed coated with littles polykote yellow, captan, thiram, gouch and super red recorded higher germination and vigour index. Similar findings were reported by Sarithadevi (2004) and Vinitha (2006) in sorghum and tomato, respectively, Selvakumari (2010) in maize hybrid and Natesan (2006) in black gram.

Ageing of seed leads to loss of seed coat semi permeability and inner content of the seeds may get dissolved in water and thereby enhances the conductivity of water used for soaking. Initially the electrical conductivity of 0.218 dSm^{-1} was recorded which got increased to 0.316 dSm^{-1} at tenth month of storage. At tenth month of storage, the seeds coated with Quick roots recorded a minimal increase in electrical conductivity and shown 8 per cent decrease over untreated control seed (Table 4). Lavanya (2009) reported that maize seed coated with polymer and imidachloprid recorded minimum increase in electrical conductivity upto the storage period of ten months. Seed health is always associated with seed quality. Healthy seeds must be free from both insect infestation and pathogen infection.

Initially there was nil pathogen infection which got increased to 2.3 per cent at tenth month of storage. It might be due to increased moisture absorption by the seeds and bare seed without protection chemicals. The seeds coated with Quick roots recorded nil pathogen infection whereas untreated control seed recorded 4.5 per cent at tenth month of storage (Table 5). Similar findings were also reported by Savitri *et al.* (1998) and Geetharani *et al.* (2006) in chilli.

Table 1. Performance of polymer coating on germination (%) of cotton seeds in storage

Polymer treatments (T)	Period of storage in months (P)										
	1	2	3	4	5	6	7	8	9	10	Mean
Untreated control	94 (75.95)	93 (74.76)	90 (71.62)	88 (69.73)	85 (67.24)	82 (64.91)	81 (64.17)	80 (63.45)	79 (62.74)	77 (61.34	**84 (67.78)**
Genius coat 171	99 (84.26)	98 (83.37)	97 (80.45)	97 (80.12)	95 (77.25)	93 (74.76)	91 (72.56)	89 (70.64)	88 (69.74)	86 (68.06)	**93 (74.76)**

Genius coat 172	96 (79.98)	95 (77.25)	95 (77.25)	94 (75.95)	91 (72.56)	91 (72.56)	88 (69.73)	86 (68.06)	85 (67.24	82 (64.91)	**90 (71.62)**
Arcus	97 (80.45)	96 (79.98)	95 (77.25)	95 (77.25)	92 (74.19)	91 (72.56)	89 (70.64)	87 (69.04)	86 (68.06)	83 (66.15)	**91 (72.56)**
Myconate	98 (83.37)	97 (80.45)	97 (80.45)	96 (79.98)	94 (75.95)	92 (74.19)	90 (71.62)	89 (70.64)	87 (69.04)	85 (67.24)	**92 (74.19)**
Quick roots	99 (84.26)	99 (84.26)	98 (83.37)	98 (83.37)	96 (79.98)	95 (77.25)	93 (74.68)	91 (72.56)	90 (71.62)	88 (69.73)	**94 (75.95)**
Mean	**97 (80.45)**	**96 (79.98)**	**95 (77.25)**	**94 (75.95)**	**92 (74.19)**	**90 (71.62)**	**88 (69.73)**	**87 (69.04)**	**85 (67.24)**	**83 (66.15)**	
	T			**P**			**T x P**				
SEd	0.558			0.721			1.767				
CD(P=0.05)	1.106**			1.428**			3.499**				

Table 2. Performance of polymer coating on root length (cm) of cotton seeds in storage

Polymer treatments (T)	**Period of storage in months (P)**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**
Untreated control	20.51	20.39	20.31	20.20	20.01	19.94	19.87	19.74	19.45	19.19	**20.02**
Genius coat 171	20.72	20.69	20.59	20.45	20.38	20.29	20.12	19.96	19.81	19.64	**20.26**
Genius coat 172	20.58	20.45	20.43	20.27	20.10	20.09	19.95	19.80	19.53	19.31	**20.05**
Arcus	20.63	20.51	20.50	20.30	20.19	20.18	20.01	19.87	19.67	19.43	**20.13**
Myconate	20.68	20.58	20.55	20.39	20.27	20.22	20.07	19.91	19.72	19.52	**20.19**
Quick roots	20.85	20.76	20.64	20.57	20.48	20.35	20.15	19.97	19.88	19.79	**20.34**
Mean	**20.66**	**20.56**	**20.50**	**20.46**	**20.24**	**20.17**	**20.03**	**19.87**	**19.67**	**19.48**	
	T			**P**			**T x P**				
SEd	0.035			0.045			0.111				
CD(P=0.05)	0.069**			0.090**			0.221**				

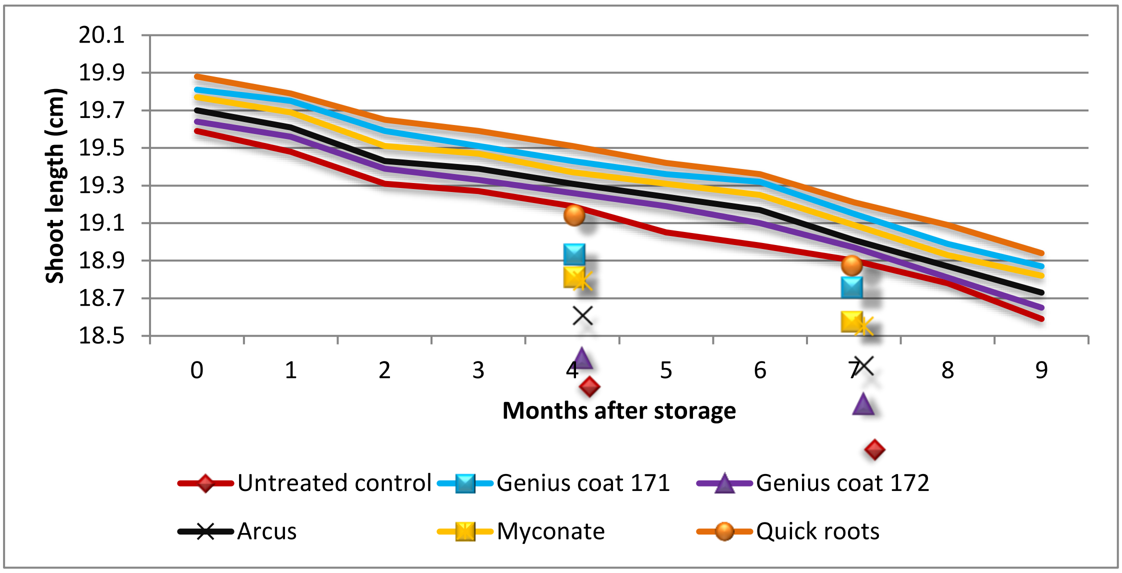

Table 3: Performance of polymer coating on vigour index of cotton seeds in storage

Polymer treatments (T)	**Period of storage in months (P)**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**
Untreated control	3769	3708	3566	3473	3332	3197	3147	3091	3020	2909	**3321**
Genius coat 171	4012	3963	3897	3876	3782	3687	3589	3481	3414	3312	**3701**
Genius coat 172	3861	3801	3783	3722	3582	3574	3436	3334	3259	3113	**3565**
Arcus	3912	3852	3793	3771	3634	3587	3487	3383	3314	3167	**3590**
Myconate	3964	3906	3886	3827	3726	3637	3539	3471	3363	3259	**3657**
Quick roots	4032	4014	3948	3936	3839	3778	3674	3565	3507	3408	**3770**
Mean	**3925**	**3878**	**3817**	**3767**	**3649**	**3576**	**3478**	**3387**	**3312**	**3216**	
	T			**P**			**T x P**				
SEd	4.555			5.881			14.406				
CD(P=0.05)	9.020**			11.645**			28.525**				

Table 4. Performance of polymer coating on electrical conductivity (dSm^{-1}) of cotton seeds in storage

Polymer treatments (T)	Period of storage in months (P)										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**
Untreated control	0.225	0.234	0.244	0.257	0.268	0.281	0.298	0.307	0.322	0.330	**0.276**
Genius coat 171	0.214	0.220	0.228	0.239	0.251	0.262	0.275	0.288	0.298	0.310	**0.255**
Genius coat 172	0.222	0.230	0.241	0.253	0.263	0.279	0.292	0.299	0.315	0.322	**0.271**
Arcus	0.219	0.227	0.239	0.248	0.260	0.273	0.285	0.297	0.310	0.319	**0.267**
Myconate	0.218	0.224	0.232	0.244	0.254	0.269	0.280	0.292	0.305	0.317	**0.263**
Quick roots	0.211	0.215	0.223	0.235	0.248	0.257	0.271	0.283	0.292	0.301	**0.253**
Mean	**0.218**	**0.225**	**0.234**	**0.246**	**0.257**	**0.270**	**0.283**	**0.294**	**0.307**	**0.316**	
	T			**P**			**T x P**				
SEd	0.001			0.001			0.002				
CD(P=0.05)	0.002**			0.002**			0.004**				

Table 5: Performance of polymer coating on pathogen infection (%) of cotton seeds in storage (Figures in parentheses are arc sine transformed values)

Polymer treatments (T)	Period of storage in months (P)										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Mean**
Untreated control	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.5 (2.10)	1.0 (4.11)	1.0 (4.11)	1.5 (6.93)	2.0 (8.13)	3.0 (9.97)	4.5 (12.22)	**1.3 (5.52)**
Genius coat 171	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.5 (2.10)	**0.0 (0.10)**
Genius coat 172	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.5 (2.10)	1.0 (4.11)	1.5 (6.93)	3.0 (9.97)	3.5 (10.75)	**0.9 (3.81)**
Arcus	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.5 (2.10)	1.0 (4.11)	2.0 (8.13)	3.0 (9.97)	**0.6 (3.21)**
Myconate	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.5 (2.10)	1.0 (4.11)	1.5 (6.93)	2.5 (9.05)	**0.5 (2.10)**
Quick roots	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	0.0 (0.10)	**0.0 (0.10)**
Mean	**0.0 (0.10)**	**0.0 (0.10)**	**0.0 (0.10)**	**0.0 (0.10)**	**0.1 (0.95)**	**0.2 (1.51)**	**0.5 (2.10)**	**0.9 (3.81)**	**1.5 (6.93)**	**2.3 (8.45)**	
	T			**P**			**T x P**				
SEd	0.030			0.039			0.096				
CD(P=0.05)	0.060**			0.078**			0.191**				

Conclusion

The cotton seeds coated with Quick roots-maintained storage potential by recording higher germination, vigour index with nil pathogen and insect infestation after ten months of storage.

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PERFORMANCE OF GARLIC VARIETIES FOR YIELD PARAMETERS

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Abstract

The present investigation was carried out to study the performance of Ninegarlic Varieties for yield parameters. Nine entries were evaluated during the Rabi season. Among thecultivar GKS 1303 recorded the maximum plant height (75.00 cm). Cultivars GKS 1301 produced the maximum number of leaves per plant (7.5). Among the yield parameters significant differences were observed in average clove weight Yield per plot, total yield (q/Ha) and Marketable yield (q/Ha) were presented table -2. GKS -1303 recorded the maximum yield of 110.6q/ha followed by GKS-1306 93.6q/ha whereas lowest yield was observed in the entry GKS-1313 47.30 q/ha. Highest Marketable yield92.00 q/ha was recorded in the entry GKS -1303 and lowest yield of38.00 q/ha was observed in GKS -1313.

Introduction

Garlic has been originated from Central Asia and it is grown throughout the world. China, India, Korea, Egypt, Russia, and Bangladesh are the major garlic producing countries. China ranks first with an area of 8.50 lakh hectares and with a production of 179.68 lakh tonnes. India ranks second with an area of 2.02 lakh ha and the production of 14.25 lakh MT (Source: FAO website). In Tamil Nadu, garlic is cultivated in 510 hectares with a production of 2890 MT and a productivity of 5.67 tonnes per hectare. The average productivity in India is low (5.69 t ha-1) compared to other countries (www.nhrdf.com). There is a growing interest for garlic among the farmers because of high returns. Hence the research work was formulated to evaluate some of the garlic varieties for high yield and screening for purple blotch under field condition.

Materials and Methods:

The present investigation was carried out at Horticultural Research Station, TNAU, The Nilgiristo evaluate nine garlic varieties which is located at 11.4025'N Latitude, 76.735' E Longitude and at an Altitude of 2635 m above Mean Sea Level. The mean annual rainfall of The Nilgiris is 1632 mm. The average maximum and minimum temperature is 26.0oC and 2 oC respectively. The average relative humidity is 75 per cent. The experiment was laid out in a Randomized Block Design (RBD) with Nine varieties replicated thrice. The garlic bulbs was sown in the plot area of 1 m2 and spacing of 15 x 10 cm. In each replication five plants were selected for recording biometrics observations on plant height (cm), number of leaves, leaf length (cm), leaf width (cm), and average clove weight (g). Total yield (q/ ha), marketable yield (q/ ha) and PDI for purple blotch. The data generated during study was subjected to statistical analysis as prescribed by Panse and Sukhatme (2000).

Result and Discussion:

Performance of different Garlic varieties showed the significant variation and presented in Table 1. The cultivar GKS 1303 recorded the maximum plant height (75.00 cm) followed by Ooty -1 (72.00 cm), GKS -1318 (73.50 cm) and GKS- 1308 (68.90 cm). Similar result were also reported by Noor et al., (1999) and Singh and Tiwari (1994), OmnarayanVerma and BhupendraThakre. 2018. Cultivars GKS 1301 produced the maximum number of leaves per plant (7.5). Variations in

leaf production could be expected among the cultivars as the attribute to a genetic character. The longest leaf length was recorded in GKS -1318 (43.00 cm) while the shortest leaf length in GKS -1323,GKS 1301 (34.00 cm).Maximum leaf width was observed in the entry Ooty-1 (2.50 cm). These findings agree with Senguptaet al., (2007).

Among the yield parameters significant differences were observed in average clove weight Yield per plot, total yield (q/ha) and Marketable yield (q/ha) were presented table -2. Among the garlic accession, maximum average clove weight was recorded in ooty-1 (22.50 g) followed by GKS -1308 (22.50 g) and GKS 1318 (19.00 g) and lowest average clove weight was recorded in GKS 1306 (11.50 g). The line with the finding of Umamaheswarappaet al., 2014. Highest Yield/Ha was ranged from 47.30 to 110.6q/ha. GKS -1303 recorded the maximum yield of 110.6q/ha followed by GKS-1306 93.6q/ha whereas lowest yield was observed in the entry GKS-1313 47.30 q/ha. Highest Marketable yieldwas recorded in the entry GKS -130392.00q/ha and lowest yield of 38.00 q/ha was observed in GKS -1313. Similar are also reported by Anand *et al*., 2019.

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Table 1. Evaluation of Garlic varieties for vegetative characters under The Nilgiris condition

Sl.No.	Name of the entry	Plant height (cm)	Number of leaves	Leaf Length (cm)	Leaf Width (cm)	Average Clove wt (g)	Marketable Yield (q/ha)	Yield/ha (q/ha)
1.	GKS-1301	65.00	7.5	34.00	1.50	17.00	51.4	66.00
2.	GKS-1303	75.00	6.5	42.50	1.60	14.00	92.00	110.6
3.	GKS-1306	57.00	5.5	36.00	1.80	11.50	90.00	93.6
4.	GKS-1308	68.90	6.5	37.00	2.00	22.50	57.00	60.00
5.	GKS-1310	70.81	6.0	42.00	1.80	17.00	58.00	69.00
6.	GKS-1313	60.52	6.0	39.00	2.00	12.00	38.00	47.30
7.	GKS-1318	73.50	6.5	43.00	1.30	19.00	45.00	59.00
8.	GKS-1320	69.00	5.5	39.00	1.50	13.00	53.00	65.30
9.	GKS-1323	57.00	5.5	34.00	1.80	13.00	65.00	70.00
10.	Ooty 1 (LC)	72.00	7.0	39.00	2.50	22.50	77.00	84.00
	SEd	4.50	0.50	2.69	0.20	2.19	3.50	3.20
	CD	9.00	1.01	5.50	0.50	4.50	4.01	6.45
	CV	7.80	8.80	8.75	11.65	6.80	6.30	13.00

ENFORCING GREEN REVOLUTION IN DRY-LANDS OF TAMIL NADU

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Abstract

The green revolution that happened in India especially in irrigated areas by mid 1960's disproved the theory of Malthusian and made India self-sufficient in food production and food secured country. But this was not sustained as latter periods because of adoption of wrong approach and methods from the main concept of green revolution by the extension managers and farmers by themselves. This led to import of food for the previous 2 years. Should we continue to permit this type of import agriculture in India? The answer should be 'No' and we must look for some alternative to sustain and enhance the food production and simultaneously looking for improving the productivity of irrigated agriculture, which was injured/damaged (plateau in irrigated crop's productivity and also decline in productivity) during first green revolution by technically, socially and politically. Since the growth rate of population is higher than the growth rate of food production presently, necessity now arises to review/ sustain our food security once again. Renowned policy makers/ senior agriculture scientists mainly converse about second green revolution and evergreen revolution concepts for India. At this context, it is why is to take a decision to shower green revolution in dry lands in India which is 93.13 m ha out of 136.18 m ha of net sown area (68.4%). In this paper the author attempts to describe the scope, methodology and management techniques to bring green revolution from dry lands of Tamil Nadu, one among the promising states of India as a case study.

Keywords: *Green revolution, dry land, growth rate, import, agricultural commodity*

Introduction

The geographical area of Tamil Nadu is 13 m ha, of which the cultivable area is 7 m ha and within this area, dry land farming is practised in 3.1 m ha. The total dry land area is distributed in the seven agro-climatic zones of Tamil Nadu and the per cent distribution is 26 per cent in North eastern zone, 24 per cent each in North western and southern zone, 12 per cent in Western zone, seven per cent in both in High rain fall and High altitude and hilly zones and six per cent Cauvery delta zone. Kannaiyan (2011) did SWOT analysis for the dry lands in Tamil Nadu and are described below;

Strength

Wide spectrum of agro-ecological and edapho-climatic conditions supporting wide bio diversity, vast network on agricultural extension, improved transportation facility, policy maker's willingness to improve dry land productivity.

Weakness

Poor soil (thirsty and hungry) and uncertain rainfall in terms, less than breakeven point income, poor financial resource of the farmers, negligence attitude of the farmers on dry land farming.

Opportunity

Potential for enhancing the productivity, political will, state plan on wasteland development, awareness on the scope of getting higher yield.

Threats

climate change, lack of leadership to initiate work, social disharmony at village level, non-availability dry land specific NGO's.

For ushering green revolution in dry lands, the strength and opportunities must be utilized efficiently and the issues related to weakness and threats must be studied in depth and solutions developed and organised for execution. The action plan is presented in the following subheads;

Infrastructure development

At every revenue village of different agro-climatic zones of Tamil Nadu where dry land area is more, a dry land society must be formed and all the farmers of the dry land must be enrolled as members by voluntary participation after explaining the concepts behind the formation. This society would be the house for procuring inputs for dry land farming and as well as the marketing channel for the produce harvested. Further a tie up may be made by the society with insurance company for crop insurance.

The members of the society will meet and prepare the plan for their dry land agriculture with inputs from extension department officials/NGO's. The members decide the technology suitable for their domain and there must not be any external pressure. Scope must be given to farmers to mix their ITK with the scientific technology already selected for their locality.

Steps may be taken to identify the existence of water shed at the revenue village level and build up management practices accordingly. If not, make a survey and develop water shed for effective resource management. All the streams within the water shed must be interconnected effectively to conserve soil and water. On long term basis attempt may be made to make Perennial River with seasonal rivers within Tamil Nadu.

Knowledge

Knowledge is the power and it triggers all activities to achieve the goal of dry land development. Village Knowledge centre must be established and there must be information flow including the weather forecast to take weather-based farm decisions.

Stitching technology bag

The members of the society by discussion select technologies from the option basket for their soil and climate condition. Similarly, they must blend their ITK's with the scientific technologies already identified for their domain and apply at the field level. It is also possible to tailor weather-based technologies from the research information already available. Based on the learning's from the past green revolution, the best technologies like Integrated Nutrient Management including balanced fertilization of NPK and organic mature application, integrated pest and disease management including bio-pesticides, technologies for value addition for the dry land produce must be given top most priority among the technologies selected for application.

Generating information and its integration

Local climatic information (Veeraputhiran *et al.*, 2013) like mean weekly values of rainfall, maximum temperature, minimum temperature, relative humidity and onset and withdrawal dates of seasonal rainfall, weekly rainfall analysis for initial probability, conditional probability, computing effective growth period, weekly wet and dry spell analysis, computing water balance on weekly basis must be made at taluk level and given to the village society as a handbook. Similarly thump rules may be given to predict pest and disease occurrence. In advance, information on the efficient cropping zone for dry land crops may be developed by employing the model of Kanwar

(1972). All the dry land areas in Tamil Nadu must have networks of rain gauges and it must be monitored at a central place for coordination and for monitoring drought occurrence.

Empowering the farmers by capacity building in dry land management

Farmers of the concerned society must be empowered through capacity building to manage their natural resources, to conserve soil and water and also to integrate the four capitals available at the village level like social, institutional, human resource and natural resource. Farmers must be empowered with meeting the challenges from three weather codes (normal, drought and flood) and they must prepare contingency plan for the three weather codes based on their past experience.

Participatory research to solve location specific problems

In any development programme, local problem may shoot up at any point of time and this must be solved through participatory research between farmers and scientists. The suggestion is to go for farmers manage trials/ superimposed trials rather than going for researcher managed trials to solve the problem.

Conclusion

This type of green revolution may be initiated on pilot basis at southern agro-climatic zones considering the vast net area on dry farming available and low backward socioeconomic development of the people living in that zone.

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RESPONSE OF KURVAI RICE TO DIFFERENT PLANTING METHODS AND LEVELS OF NPK NUTRIENTS

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Abstract

Rice is the predominant food crop for millions of people around the globe. Rice is livelihood for the farmers of Indian sub-continent. Rice plays a major role in Indian agriculture and it contributes about 19.9 per cent of annual and delivers 43 per cent calorie requirement for more than 70 per cent of Indians. In India, it is cultivated in an area of 44 million hectares which is maximum among all rice growing countries with an annual production of about 120 million tonnes with a productivity of 2390 kg ha^{-1} (Anonymous, 2019). Food security is the major challenge for the world by ever increasing food demand on one hand and threatened by declining water availability on other hand. Exploring various ways to produce more rice with less water is indispensable for food security.

Introduction

The System of Rice Intensification (SRI) is a method of rice cultivation which offers an opportunity for reducing water demand accompanied by yield augmentation of rice (Thakur *et al*., 2014). Planting of tiny single seedling was one of the major constraints under large scale adoption of SRI farmers (Porpavai and Jayaraj, 2008). Anitha and Usha (2008) yield enhancement in rice was noticed under planting of two seedlings hill^{-1}, intermittent irrigation and conoweeding under SRI method. Better agronomic strategies *viz*., nutrient management and planting methods would be implemented to harness the yield of rice. Rice crop responds upto 175 kg N ha^{-1} (Subramanian and James Martin, 2007). This is the right time to modify the location specific technologies. Keeping in view, of all the above consideration, the present investigation was attempted to optimum nutrient level to increase the rice grain yield.

Materials and methods

The field trial was carried out in kuruvai season (June – September 2010) at Annamalai University Experimental Farm, Annamalainagar, Cuddalore District, Tamil Nadu, and India. The experimental field soil was clay loam with low in available nitrogen, medium in available phosphorus and high in available potassium. Rice cv.ADT-43 was chosen for the study. The field experiment was under split plot design with three replications. Three main plot treatments *i.e.*, nutrient levels comprised of 120:38:38 kg N, P_2O_5 and K_2O ha^{-1} (N_1 – 100% RDF), 150:47.5:47.5 kg N, P_2O_5 and K_2O ha^{-1} (N_2 – 125% RDF) and 90:28.5:28.5 kg N, P_2O_5 and K_2O ha^{-1} (N_3 – 75% RDF). The subplot treatments (planting methods) *viz*., SRI with one seedling hill^{-1} (P_1), SRI with two seedlings hill^{-1} (P_2), SRI with three seedlings hill^{-1} (P_3), conventional method of line planting (P_4) and conventional method of random planting (P_5). For conventional planting, the recommended quantity of paddy seeds (60 kg ha^{-1}) was sown in a nursery area of 800 m^2.

The sprouted seeds were sown in the prepared nursery beds. Alternative drying and wetting was practiced for the first four days till sufficient germination was noticed. For SRI method dapog nursery beds were prepared on a polythene sheet or fertilizers bags with lower 5 cm sand layers above which soil of the experimental site was spread to l cm thickness. In SRI method, weeding was done using a cono weeder from 10 days after transplanting up to that turns up the surface soil

to remove weeds and provides additional aeration. As far as conventional method is concerned, two hand weeding was done at 20 and 40 DAT. In SRI, irrigation was given as a thin film of water depending on the soil condition (till a hair line crack appeared) up to vegetative stage of the crop and later till physiological maturity, 2-3 cm of standing water column was maintained.

Results and Discussion

Growth parameters

The growth performance of rice with various nutrient management practices and planting methods are presented in table1.

Table 1. Response of different Planting methods and levels of NPK nutrients on the growth kuruvai Rice

	Plant height at harvest (cm)	**Number of tillers m^{-2}**	**DMP (kg ha^{-1})**
Main plot-Nutrient Level			
N1 -100% RDF	94.26	387	9058
N2 -125% RDF	98.16	413	10778
N3 -75% RDF	90.44	359	7667
SEd	0.47	2.13	63.4
CD(p=0.05)	1.31	5.9	176
Sub plot- Planting methods			
P_1 – SRI with one seedling $hill^{-1}$	98.44	302	9767
P_2 – SRI with two seedlings $hill^{-1}$	95.63	362	10848
P_3 – SRI with three seedlings $hill^{-1}$	95.28	360	9752
P_4 – Line planting	92.50	466	8424
P_5 – Random planting	89.58	443	7048
SEd	0.55	2.7	73.3
CD(p=0.05)	1.26	6.4	169

Plant height was significantly altered due to various nutrient levels. The tallest plants with 98.16 cm at harvest were recorded with 125 per cent recommended dose of fertilizers (RDF). i.e.150:47.5:47.5 kg N, P_2O_5 and K_2O ha^{-1} and was significantly higher to 100% RDF and 75% RDF. The DMP differed significantly due to varying level of nutrients. The highest DMP of 10778 kg ha^{-1} at harvest was recorded under 125% RDF. The least DMP was perceived with 125 per cent RDF. Earlier reports on higher plant height, larger leaf area index, dry matter production (Bejbaruah *et al.*, 2009) due to higher level of NPK application were in line with the present findings.

Significant variation in plant height was observed among different planting methods. The higher plant height of 98.44 cm at harvest was obtained under planting of one seedling under SRI when compared to other planting methods. The least plant height (89.58 cm) was recorded with random planting. The highest plant height under SRI was noticed due to wider spacing coupled with square planting leads to less competition. The largest number of 466 tillers m^{-2} was recorded in line planting. Planting of SRI with two seedlings $hill^{-1}$ registered significantly higher dry matter

production of 10848 kg ha^{-1}. Planting of SRI with three seedlings hill^{-1} and one seedlings hill^{-1} were on par with each other with respect to dry matter production.

Yield parameters

The yield attributes and yield of rice about nutrient management practices and planting methods are depicted in table 2.

Table 2. Planting methods and nutrient management practices on the yield kuruvai Rice

	Number of panicles m^{-2}	Number of filled grains panicle^{-1}	Thousand grain weight (g)	Grain yield (kg ha^{-1})
NutrienT level				
N1 (100% RDF)	313	94	15.66	4211
N2 (125% RDF)	344	105	1569	4985
N3 (75% RDF)	281	86	15.54	3385
SEd	1.48	1.01	0.3	49
CD(p=0.05)	4.1	2.8	NS	138
Planting Methods				
P_1 – SRI with one seedling hill^{-1}	258	119	15.89	4429
P_2 – SRI with two seedlings hill^{-1}	319	111	15.73	4966
P_3 – SRI with three seedlings hill^{-1}	305	101	15.54	4347
P_4 – Line planting	353	77	15.49	3850
P_5 – Random planting	328	68	15.49	3378
SEd	2.26	1.43	0.4	53
CD(p=0.05)	5.2	3.3	NS	123

Among the different nutrient levels tested, application of 150:47.5:47.5 kg N, P_2O_5 and K_2O ha^{-1} disclosed the highest number of panicles m^{-2}, number of filled grains panicle ^{1}. The highest grain yield of 4985 Kg ha^{-1} was attained with150:47.5:47.5 kg N, P_2O_5 and K_2O ha^{-1} application.

Among the various planting methods, the maximum number of panicles m^{-2} (353) was recorded in line planting. Highest number of filled grains per panicle (119) was noticed under planting of SRI with one seedling hill^{-1} it was followed by planting of SRI with two seedling hill^{-} The lowest number of panicles m^{-2} (328) was observed with random planting. more number of filled grains paicle^{-1} might be due to the availability of more sunlight and prevailing of less competition among the plant for nutrients at wider spacing. Similar results were reported by Anitha and Usha (2008). Planting of two seedlings hill^{-1} under SRI resulted in largest grain yield of 4900 kg ha^{-1}

Conclusion

This present study clearly showed that transplanting rice seedling under SRI with two seedlings per hill along with with150:47.5:47.5 kg N, P_2O_5 and K_2O ha^{-1} application for yield enhancement Kuruvai rice in the tail end of Cauvery Delta zone.

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COMBINING ABILITY AND NATURE OF GENE ACTION IN BHENDI (*Abelmoschus esculentus* L.) MOENCH)

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Abstract

The investigation carried out on bhendi consisted of 12 parents (9 lines and 3 testers) with their 27 F_1 hybrids developed through line x tester mating design with three replications in randomized block design. Parents and hybrids differed significantly for GCA and sca effects, respectively. The results showed that GCA effects of parents and sca effects of hybrids were significantly differed. Among the parents, maximum GCA effect was found in EC 102605 and Kashi Kranti for days to first flowering, EC 112112, and Kashi Kranti for days to first fruit harvest and EC 109454 and Arka Anamika for number of immature seeds per fruit. The cross combinations EC 102605 x Aruna, EC 112112 x Kashi Kranti and EC 169335 x Aruna exhibited maximum significant negative sca effects for days to first flowering, days to first fruit harvest and number of immature seeds per fruit respectively. The SCA variance was higher than the GCA variance that indicates the presence of preponderance of non-additive gene action for days to first harvest and number of immature seeds per fruit. The GCA variance was higher than the SCA variance that indicates the presence of preponderance of additive gene action for days to first flowering.

Introduction

Bhendi [*Abelmoschus esculentus* (L.) Moench] popularly known as Ladies finger or Okra or Bhindi comes under the family of Malvaceae with chromosome no: 2n=2x=130. It is originated in Tropical Africa. Bhendi is used for treating genitor-urinary disorder, chronic dysentry and spermatorrhoea. The roots and stems of okra are used for clarification of sugarcane juice before it is converted into jaggery and brown sugar (Fageria *et al.*, 2012). Mature fruits and stems of okra containing crude fibre are used in the paper industry. The mature seeds of bhendi are roasted, ground and used as substitute for coffee in some countries (Dhande *et al.*, 2012). Dry seeds of okra contain 13-22 % of edible oil and 20-24 % of protein. The oil is used in soap and cosmetic industry and the protein is used for fortified feed preparations. The concept of combining ability plays an important role in selection of parents and production of superior hybrids. The general combining ability (GCA) and specific combining ability (sca) is a foundation for any breeding programme. The general combining ability is the manifestation of additive gene action for the selection of parents and the specific combining ability in respect of a particular character of a hybrid is the capitalization of non-additive gene action. The present study carried out to identify the nature of

gene action, general combining ability (GCA) of the parents and specific combining ability (sca) of the hybrids on earliness characters.

Materials and methods

The present investigation comprised of twelve parents which involved nine lines, three testers and twenty-seven F_1 hybrids. The plants were raised in three replications at spacing of 45 x 30 cm in Randomized Block Design (RBD) during December to February, 2020 was carried out at Vegetable Unit, Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar. Many biometrical procedures were used for studying the combining ability, Line x Tester is one of the efficient method was developed by Kempthorne (1957), which is good method for evaluating the large number of genotypes at a time for combining ability variances and effects. Recommended cultural practices were followed to raise a successful crop. Five plants of each entry in each replication were randomly selected for recording the observations on days to first flowering, days to first fruit harvest and number of immature seeds per fruit.

Result and discussion:

The analysis of variance (Table 1.) showed all the lines and testers were significant for all the characters. The variance due to lines x testers interaction was significant for number of immature seeds per fruit, there by showing high specific combining ability. The variance due to hybrids was significant for all the characters.

Table 1. Analysis of variance for biometric characters in bhendi

Source	DF	Days to first flowering	Days to first fruit harvest	Number of immature seeds per fruit
Replication	2	0.58	0.61	0.01
Lines	8	8.40**	2.60**	19.58**
Testers	2	75.34**	30.11**	286.86**
Lines x testers	16	1.32	0.10	35.85**
Hybrids	26	9.20**	3.72**	50.16**
Error	76	0.95	0.75	0.02

*Significant at 5% level, **significant at 1% level.

Combining ability

General combining ability effect (GCA effect):

The success of any breeding programmes is highly depends on selection of parents and breeding procedure adopted. To study the combining ability is an efficient biometrical tool used to discriminate good and poor combiners and for choosing suitable parents in hybridization programmes (Bhatt *et al.*, 2014). Singh *et al.* (2012) opined that choosing parents based on combining ability is a prerequisite for any breeding programmes and it's provide information about nature and magnitude of gene action in the desirable traits.

The GCA effects (Table 2) of lines and testers ranged from -1.64 to 1.36 and -1.37 to 1.86 respectively. Among the lines, EC 102605 recorded maximum negative significant GCA effect (-1.64) followed by EC 169335 (-0.73) and EC 112112 for days to first flowering. Among the

testers, the highest negative significant GCA effect was found in Kashi Kranti (-1.37) and Arka Anamika (-0.49). The results are in conformation with earlier findings of Balakrishnan *et al*. (2009), Bhatt *et al*. (2015), Wakode *et al*. (2016), Eswaran and Anbanandan (2018) and Sapavadiya *et al*. (2019).

The GCA effects of lines and testers ranged from -0.86 to 0.79 and -0.91 to 1.16 respectively. Among the lines, EC 112112 (-0.86) and EC 102605 (-0.68) recorded maximum negative significant GCA effect for days to first fruit harvest. Among the testers, the highest negative significant GCA effect was found in Kashi Kranti (-0.91). The results agree with the findings of Jindal and Ghai (2005), Wakode *et al*. (2016), Devi *et al*. (2017), Makdoomi *et al*. (2018) and Padadalli *et al*. (2019).

The range of GCA effects varied from -2.01 to 2.06 and -2.52 to 3.68 for lines and testers respectively. Among the parents EC 109454 and Arka Anamika recorded maximum negative significant GCA effect (-2.01) and (-2.52) respectively for number of immature seeds per fruit. However, this is the conformity with the findings by Weerasekara *et al*. (2008), Solankey and singh (2010), Sawadogo *et al*. (2014), More *et al*. (2015), Shwetha *et al*. (2018) and Joshi *et al*. (2019).

Table 2. Estimates of general combining ability effects of parents for yield and quality attributes of bhendi

Parents	**Days to first flowering**	**Days to first fruit harvest**	**Number of immature seeds per fruit**
Lines			
Ec 102605	-1.64**	-0.68*	1.66**
Ec 112112	-0.69*	-0.86**	-0.01
Ec 112264	-0.13	-0.04	-1.34**
Ec 109454	-0.06	0.28	-2.01**
Ec 112241	1.36**	0.79**	-0.47**
Ec 169329	0.76*	0.50	-1.01**
Ec 169344	0.00	-0.17	-0.61**
Ec 169331	1.14**	0.32	1.73**
Ec 169335	-0.73*	-0.14	2.06**
SE for lines	**0.31**	**0.30**	**0.04**
Testers			
Arka Anamika	-0.49**	-0.25	-2.52**
Kashi Kranti	-1.37**	-0.91**	-1.16**
Aruna	1.86**	1.16**	3.68**
SE for testers	**0.20**	**0.20**	**0.02**

*significant at 5% level, **significant at 1% level.

Table 3. Estimates of specific combining ability effects of hybrids for yield and Quality attributes of bhendi

Hybrids	**Days to first flowering**	**Days to first fruit harvest**	**Number of immature seeds per fruit**
Ec 102605 x AA	0.12	0.23	3.05**
Ec 102605 x KK	0.79	0.42	-0.90**
Ec 102605 x A	-0.91	-0.65	-2.15**
Ec 112112 x AA	0.43	0.74	-1.68*
Ec 112112 x KK	-0.70	-0.67	1.36*
Ec 112112 x A	0.27	-0.07	0.32**
Ec 112264 x AA	0.27	0.30	-1.15**
Ec 112264 x KK	-0.52	-0.48	0.09**
Ec 112264 x A	0.25	0.19	0.25**
Ec 109454 x AA	0.20	0.34	4.52**
Ec 109454 x KK	0.35	0.13	-2.44**
Ec 109454 x A	-0.55	-0.47	-2.08**
Ec 112241 x AA	0.38	-0.57	0.79**
Ec 112241 x KK	-0.28	0.22	-2.17**
Ec 112241 x A	-0.11	0.35	1.39**
Ec 169329 x AA	-0.22	0.12	-3.48**
Ec 169329 x KK	0.19	-0.09	1.16**
Ec 169329 x A	0.03	-0.03	2.32**
Ec 169344 x AA	-0.60	-0.61	-2.68**
Ec 169344 x KK	-0.45	-0.43	-3.84**
Ec 169344 x A	1.05	1.04*	6.52**
Ec 169331 x AA	-0.60	-0.37	0.39**
Ec 169331 x KK	-0.12	0.35	1.43**
Ec 169331 x A	0.72	0.02	-1.81**
Ec 169335 x AA	0.00	-0.17	0.25**
Ec 169335 x KK	0.75	0.55	4.50**
Ec 169335 x A	-0.75	-0.38	-4.75**
SE for crosses	**0.54**	**0.50**	**0.10**

AA – Arka Anamika, KK – Kashi Kranti, A – Aruna.
*significant at 5% level, **significant at 1% level.

Specific combining ability effect (SCA effect)

The specific combining ability is an important criterion for assessing the hybrids. Spraque and Tatum (1942) opined that the specific combining ability was controlled by non-additive gene action. The sca effects (Table 3) of hybrids, the maximum negative non-significant sca effect was observed in EC 102605 x Aruna (-0.91) followed by EC 169335 x Aruna (-0.75) and EC 112112 x Kashi Kranti (-0.70) for days to first flowering. This is in consonance with the results of Prakash et al. (2012), Kishore et al. (2013), More et al. (2015), Tiwari et al. (2016) and Kayande et al. (2018).

Among the hybrids, the maximum negative non-significant sca effect was observed in EC 112112 x Kashi Kranti (-0.67) followed by EC 102605 x Aruna (-0.65) and EC 169344 x Arka Anamika (-0.61) for days to first fruit harvest. Similar results observed by Jagan *et al*. (2013), Satish *et al*. (2017), Tiwari *et al*. (2016), Punia and Garg (2019), Padadalli *et al*. (2019) and Sapavadiya *et al*. (2019).

Among the hybrids, the highest significant negative sca effect was reported on EC 169335 x Aruna (-4.75) followed by EC 169344 x Kashi Kranti (-3.84) and EC 169329 x Arka Anamika (-3.48) for number of immature seeds per fruit. The results are in agreement with Sharma and Singh (2012), Nagesh *et al*. (2014), Raju and Selvam (2017) and Makdoomi *et al*. (2018).

Table 4. Analysis of combining ability variance for biometric characters in bhendi

Variance	Days to first flowering	Days to first fruit harvest	Number of immature seeds per fruit
GCA variance	0.162	0.056	0.295
SCA variance	0.150	0.099	11.946
GCA/ SCA	1.08	0.566	0.025

Gene action

According to Tai (1979), the success of any plant breeding programme is mainly depends on greater extend of knowledge on the genetic architecture of the population handled by the breeder. For above information knowledge on the relative importance of the GCA and SCA variances is more useful. The line x tester analysis is provides information about nature of gene action which expressed as the ratio of GCA and SCA variance. The GCA variance is greater than SCA variance that indicates the presences of preponderance of additive gene action and if SCA variance is greater than GCA variance that indicates the presence of preponderance of non-additive gene action.

The results of combining ability variances (Table 4) are revealed that the SCA variance were higher than the GCA variance for all the characters except days to first flowering. The ratio of GCA/SCA were days to first flowering (1.08), days to first harvest (0.566) and number of immature seeds per fruit (0.025). The SCA variance was higher than the GCA variance that

indicates the presence of preponderance of non-additive gene action for days to first harvest and number of immature seeds per fruit. In respect to days to first flowering, the GCA variance is greater than SCA variance that indicates the presences of preponderance of additive gene action. This is consonance of same results found by Mehta *et al.* (2007), Gendy *et al.* (2012), Hamada *et al.* (2015), Verma and Sood (2015) and Rameshkumar *et al.* (2017).

Conclusion

From the above discussion that could be concluded with the first top ranking hybrids had either one of the parents as good general combiner for all the characters. Hence, these cross combinations will be used in future hybridization programme for further improvement.

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EFFECT OF PRUNING SEASON AND GROWTH RETARDANTS ON OFF-SEASON PRODUCTION OF ANNUAL MORINGA

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Abstract

Moringa oleifera is an Angiospermic plant commonly known as the 'drumstick' or 'horseradish' tree. Present study was carried out during 2021 – 2022 in Perampattu village, near Chidambaram Taluk, Cuddalore District. The research comprised of three pruning levels (P1 - October pruning, P2 - November pruning and P3 - December pruning) and five levels of chemical spray (G1 - water spray (Control), G2 - uniconazole 50 ppm spray, G3 - uniconazole 40 ppm spray, G4 - mepiquat chloride 50 ppm spray, G5 -mepiquat chloride 40 ppm spray) comprising fifteen treatment combinations with two replications under factorial randomized block design (FRBD). Observations on growth, yield and quality characters were recorded. Among the fifteen different treatments, T3 – P1 x G3 (October pruning and uniconazole 50 ppm spray) recorded the highest values for growth parameters viz., plant height (3.58 m), number of primary branches tree-1 (6.31) and it was followed by T5 – P1 x G5 (October pruning and mepiquat chloride 50 ppm spray). The treatment combination T3 – P1 x G3 (October pruning and uniconazole 50 ppm spray) recorded the highest values for yield parameters viz., Days to first flowering (71.98 days), number of panicles tree-1 (47.88), number of flowers panicle-1 (65.23), number of pods panicle-1 (2.00), pod set percentage panicle-1 (2.78), pod length (63.52 cm), pod girth (1.90 cm), single pod weight (84.29 g), number of pods tree-1 (89.06) and estimated total pod yield (16.00 kg tree-1). The least values were recorded in T11 – P3 x G1 (December pruning and water spray). Regarding quality parameters, treatment T3 – P1 x G3 (October pruning and uniconazole 50 ppm spray) recorded the highest value in protein content in pod (2.38 g 100 g-1) and it was followed by T5 – P1 x G5 (October pruning and mepiquat chloride 50 ppm spray). T5 is on par with T4 - P1 x G4 (October pruning and mepiquat chloride 40 ppm spray).

Based on the growth, yield, quality and cost economics the combined treatment of October pruning + uniconazole 50 ppm spray can be considered as the best treatment for the off-season production of Annual moringa.

Introduction

Moringa (*Moringa oleifera* Lam.) popularly called as the “drumstick tree” which is an indigenous vegetable. *Moringa oleifera* belongs to the monogeneric family Moringaceae which has 13 diverse species in it. Among them, Moringa oleifera is the most popular species with multitude use (Reyes, 2006). Moringa tree though native in the sub – Himalayan tracts, it is widely cultivated in Africa, Central and South America, Sri Lanka, India, Mexico, Malaysia, Indonesia and the Philippines (Anwar and Bhanger. 2003).

Moringa leaves contain fiber, fat, proteins and minerals like Ca, Mg, K, P, Fe, Cu, and S. Vitamins like Vitamin-A (Beta-carotene), vitamin B-choline, vitamin B1-thiamine, riboflavin, nicotinic acid and ascorbic acid are present. Various amino acids like His, Arg. Trp. Lys, Thr, Phe, Leu, Ile, Met, Val are present. Phytochemicals like sterols, tannins, trepenoids, saponins, alkaloids, phenolics and flavonoids like isoquercitin, isothiocyanates, quercitin, kaemfericitin, and glycoside. Compounds are present (Jung, 2014).

Moringa seed contains antibiotic (pterygospermin), fatty acids like linolenic acid, linoleic acid, behenic acid and oleic acid (Ben oil); Phytochemicals like saponin, tannins, phytate, phenolics, terpenoids, flavonoids and lectins. The moringa pods rich in lipids, fiber, non-structural carbohydrates and protein (Thruber *et al*., 2010). There are many uses of moringa tree and these will all be: medicines, human food, water purification, animal fodder, alley cropping, fertilizer, living fence, domestic cleaning agent, fuel wood and other uses.

India is the largest producer of moringa with an area of 93.91 thousand hectares and production at 1.3 MT. Andhra Pradesh as the largest producer among the states, followed by Karnataka and Tamil Nadu in both area and production (Ambadas *et al*., 2021). In Tamil Nadu, it is cultivated in 18.19 thousand hectares with a production of 7.35 lakhs tonnes. The major area is under moringa cultivated in the districts of Dindigul, Theni, and karur, Thoothukudi, Ariyalur and Tirupur.

Originally moringa is considered as a tree of hot semi-arid regions (Annual rainfall 250-1500 mm), which is adaptable to a wide range of environmental conditions: from hot dry to hot, humid and wet conditions. Moringa is quite drought tolerant and is well suited for a wide range of adverse environments.

Moringa has a lot of promise, but it can only be completely realised if the crop is pruned at the suitable time. Optimal pruning improves the conditions for plant growth in terms of light, nutrition, and moisture, resulting in the early onset of the reproductive period and, as a result, the formation of more fruits.

Growth retardants are diverse groups of chemicals having common physiological effect of reducing stem growth by inhibiting cell division of the sub-apical meristem. Growth retardation is primarily induced by inhibition of gibberellin biosynthesis between kaurene and kaurenoic acid. The effects of growth retardants on crop plants include slowing vegetative development and encouraging blooming (Sharmila Bharathi, 2014).

However, further research into the physiological mechanisms of flowering in response to climatic conditions, as well as modifying flowering behaviour to suit off-season output, is essential. Off-season output can be aided by changing the flowering mechanism by raising the, pruning practices, and using growth retardants.

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EFFECT OF DIFFERENT WEED MANAGEMENT PRACTICES ON WEED DENSITY, YIELD AND ECONOMICS OF MAIZE (*Zea mays* L.)

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Abstract

A field experiment was carried out at a farmer's field in the Perambalur District of Tamil Nadu, India, during the Kharif season of 2021 to ascertain the effects of various weed management methods on the weed density, yield and economics of maize. The study comprised ten treatments (Pre application of Atrazine was fb post emergence application were 2, 4-D, Halosulfuron methyl, Tembotrine, Tembotrine+ Atrazine, Mesotrione + Atrazine) and was set up in a randomised block design. Hand weeding on 15 and 30 DAS ranked first and resulted in the lowest weed count on 30 DAS (Grasses – 3.20, Sedges – 6.24, BLW's – 12.34), weed count on 45 DAS (Grasses – 2.73, Sedges – 3.12, BLW's – 6.34) with grain yield of 4482 kg/ha and stover yield of 5720 kg/ha. The highest gross monetary was recorded in hand weeding (₹108806) and net monetary was recorded in Atrazine 0.5 kg a.i/ha on 3 DAS fb Post emergence application of Tembotrine 105 g/ha on 20 DAS (₹61052) with BCR of 2.29.

Introduction

Maize is referred to as the "Queen of Cereals" because to its photothermo-insensitive traits and maximum genetic yield potential among cereals. In most of the states of India, maize is cultivated all year round for several uses including food, feed, fodder, green cobs, sweet corn, baby corn, popcorn, and industrial items. In India, maize may be grown in three different seasons' *viz.*, *kharif*, *Rabi* in peninsular India and Bihar and *spring* in Northern India. Although it is typically grown during the *kharif* season, winter maize has recently become a substantial part of India's overall maize output (Singh *et al.*, 2012). Weeds are one of the biggest threats to the agro-ecosystem facing crops today, negating any possible advantages their genetic makeup may have (Kumar *et al.*, 2016). Except for changing climatic conditions, agronomic management strategies have the greatest impact on the heterogeneity of weeds in agro-ecosystems (Kumar *et al.*, 2018). Fertilizer modifies soil fertility, which impacts crop development as well as weed variety and growth (Ghosh *et al.*, 2018). Due to the convenience of use, fast results and long-lasting phytotoxic effect on weeds, the use of herbicides to manage weeds is currently a practice that is widely recognized (Banerjee *et al.*, 2019). The frequent use of herbicides with the same mode of action, reduced selectivity as a result of overuse, a lack of knowledge about herbicides, herbicide load in the food chain, etc. have all contributed to the emergence of herbicide-resistant weeds. Additionally, a trade-off is created between workload, produce quality and environmental effects. These problems highlighted the requirement to hunt for an alternate, environmentally acceptable weed control method in agricultural production (Ghosh *et al.*, 2017). As a result, combining chemical and mechanical weed management techniques typically results in more effective weed control than using only chemicals (Ghosh *et al.*, 2020).

Materials and Methods

During the *kharif* season of 2021, the current field experiment was conducted in a farmer's field in Kurmalur village, Perambalur District, Tamil Nadu, India. The experimental field is located

at $11^o14'$ North latitude and $78^o47'$ East longitude, with a height of 143 metres above sea level. The soil texture is sandy loam, with a pH of 8.32 and a conductivity of 0.15 dSm^{-1} at the experimental site. Nitrogen, phosphorus, and potassium availability were low, medium, and high, respectively, at the experimental site. During the crop season, 644 mm of rainfall received over 54 days, with average maximum temperatures ranged from 24.4^0C to 36.6^0C and minimum temperatures ranged from 20.3^0C to 24.6^0C.

The weed management options were separated into 10 treatments and were laid in a randomised block design with three replications, namely T_1 - Control, T_2 - Hand weeding on 15 and 30 DAS, T_3 - Atrazine 0.5 kg a.i//ha as a PE on 3 DAS *fb* Tembotrine 105 g/ha as a PoE application on 20 DAS, T_4 - Atrazine 0.5 kg a.i /ha as a PE application on 3 DAS *fb* 2,4-D @ 1 kg/ha as a PoE application on 20 DAS, T_5 - Atrazine 0.5 kg a.i /ha as a PE application on 3 DAS *fb* Halosulfuron methyl 75% WDG @ 90 g/ha PoE application on 20 DAS, T_6 - Tembotrine 105 g/ha as a PoE application (3rd Leaf stage of weeds), T_7 - Tembotrine 105 g/ha + Atrazine 0.5 kg a.i/ha as a PoE application (3rd Leaf stage of weeds), T_8 - Tembotrine 105 g /ha as a PoE application (3rd Leaf stage of weeds) *fb* Hand weeding on 30 DAS, T_9 - Halo sulfuron methyl 75% WDG @ 90 g /ha on PoE application 20 DAS, T_{10} - Mesotrione + Atrazine 3.5 l /ha on 3rd leaf stage of weeds. According to the treatment plan, herbicide spraying was done using a knapsack sprayer with a flat fan nozzle and 500 litres of water per hectare. Atrazine, a pre-emergence herbicide, was administered as instructed on 3 DAS and 2,4-D, Halosulfuron methyl, Tembotrine and Mesotrione + Atrazine, post-emergence herbicides were treated as instructed. On 15 and 30 DAS, weeding was carried out manually in line with the treatments. Crop observation was done on 30, 60, and harvest days. The observation of weeds was carried out at 15, 30 and 45 DAS. 0.25 m^2 quadrats were randomly positioned at each site to observe weeds. A need-based approach to plant protection was taken based on the economic threshold of pests and diseases. For this experiment, the maize hybrid NK 6240 was chosen and it was seeded at a 60 x 20 cm spacing. Urea, single super phosphate, and potash murate were combined to create a fertiliser dosage of 60:30:30 NPK kg/ha. At the beginning, the full dosages of P_2O_5 and K_2O as well as half of the allowed N were administered. The remaining N was applied on top as a dressing. Using Gomez and Gomez's (1984) method, biometric data obtained from plant samples and computed data were all statistically examined. The critical difference was determined at a 5% probability level in cases where the F test indicated that the treatment difference was significant. The weed density underwent square root modifications using the formula.

Results and Discussion

Pre-emergence herbicide treatment followed by post-emergence herbicide application was shown to be the most significant difference between the various weed controls techniques used in the trial. The weed count was done on 15 DAS and the pre-emergence applied treatment showed a substantial difference from the non-pre-emergence treated plot. The Pre emergence application of Atrazine @ 0.5 kg a.i/ha on 3 DAS reported the lowest weed count among the various treatments tested. The broad leaf weeds are more prevalent in the control plot (weed count: 56.33), followed by sedges (weed count: 34.46) and grasses (weed count: 27.54). The weed count was measured over the course of 30 DAS. Hand weeding recorded the lowest weed infestation of any treatment, which was followed by pre-emergence applications of atrazine (0.5 kg/ha on 3 DAS) and tembutrine (105 g/ha on 20 DAS). Hand weeding resulted in a 36.45 rise in grass weeds, a 43.46 increase in sedge weeds and a 62.07 increase in broad leaf weeds when compared to the control treatment. Hand weeding twice on 15 and 30 DAS, together with pre-emergence applications of

atrazine 0.5 kg a.i/ha and tembotrine 105 g/ha, were applied on DAS 45 to reduce the amount of weed infestation.On comparing with hand weeding on 15 and 30 DAS with Pre emergence application of Atrazine 0.5 kg a.i/ha on 3 DAS *fb* Post emergence application of Tembotrine 105 g/ha on 20 DAS, the weeds count in the treatment plot recorded the 0.17 in grasses, 0.32 in sedges and 0.34 in broad leaves weeds. Pre-emergence atrazine suppression of the weed population was followed by post-emergence sequential application of tembotrine (0.105 kg/ha) to control the second flushes of weeds. This result was corroborated with the result of Verma *et al.* (2018).

The manual weeding on 15 and 30 DAS treatments, which resulted in a grain yield of 4482 kg/ha was followed by the pre-emergence application of Atrazine @ 0.5 kg a.i/ha, on 3 DAS fb. Tembotrine 105 g/ha was applied post-emergence on 20 DAS with 4469 kg/ha. The grain production was enhanced by up to 13 kg/ha by hand weeding on 15 and 30 DAS as opposed to pre-emergence followed by post-emergence applications of atrazine and tembotrine. With 1386 kg/ha, the control treatment produced the least amount of grain. The stover production was greater after manual weeding twice on 15 and 30 DAS, which was followed by pre-emergence applications of Atrazine (0.5 kg/ha) and Tembotrine (105 g/ha) on 3 and 20 DAS, respectively. The stover yield was enhanced 2748 kg/ha and 2736 kg/ha in comparison to control when manual weeding was used on 15 and 30 DAS, as well as pre-emergence applications of Atrazine (0.5 kg a.i/ha) on 3 DAS and Tembotrine (105 g/ha) on 20 DAS. The control had the lowest yield of stover, at 2972 kg/ha.This may be primarily because there were fewer weeds and their growth, which provided an environment free of weeds during the early and later stages of crop growth. As a result, all the resources for growth were used to their fullest extent by the crop plants, resulting in better vegetative growth and reproductive potential, which was evident in increased growth parameters, yield attributes, and yield as reported by Mitra *et al.* (2018).

Based on an average B: C ratio, pre-emergence applications of Atrazine (0.5 kg/ha) and Tembotrine (105 g/ha) were sprayed on days of 3 and 20. Hand weeding was done twice on days 15 and 30. This may be because these treatments produced high seed yields due to superior weed management. Due to higher weed density and lower yield, the gross financial return (GMR), net financial return (NMR), and B: C ratio were all at their lowest in weedy checks. The maximum net financial amount was recorded in the pre-emergence of atrazine followed by post-emergence treatment of Tembotrine (105 g/ha) on 20 DAS with ₹61052, while the highest gross financial amount was recorded in the hand weeding (₹108806). The entry of costs for weed management in the field may be the cause of the difference between net and gross financial.Similar result were obtained byGupta *et al.* (2018).

Conclusion

Although the weed-free treatment produced the highest grain yield (4482 kg/ha) due to the lowest weed density, it could not be as profitable as herbicidal treatments like pre-emergence application of Atrazine (0.5 kg/ha) and post-emergence application of Tembotrine (105 g/ha) on 20 DAS due to higher costs associated with hiring more labour.

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Table 1 Effect of different weed management practices on weed density and yield of maize

Treatment	Weed Density – 15 DAS			Weed Density – 30 DAS			Weed Density – 45 DAS			Grain Yield (kg/ha)	Stover Yield (kg/ha)
	Grass	Sedges	BLW	Grass	Sedges	BLW	Grass	Sedges	BLW		
T_1	27.54 (5.30)	34.46 (5.91)	56.33 (7.54)	39.65 (6.34)	49.70 (7.09)	74.41 (8.66)	42.50 (6.56)	61.54 (7.88)	89.72 (9.50)	1386	2972
T_2	26.11 (5.16)	32.53 (5.75)	53.03 (7.32)	3.20 (1.92)	6.24 (2.60)	12.34 (3.58)	2.73 (1.80)	3.12 (1.90)	6.34 (2.62)	4482	5720
T_3	4.16 (2.16)	8.11 (2.93)	15.22 (3.96)	3.90 (2.10)	6.84 (2.71)	12.93 (3.66)	2.90 (1.84)	3.44 (1.98)	6.68 (2.68)	4469	5708
T_4	4.71 (2.28)	8.67 (3.03)	15.85 (4.04)	6.20 (2.59)	10.40 (3.30)	18.15 (4.32)	4.58 (2.25)	6.11 (2.57)	8.23 (2.95)	3960	5164
T_5	4.98 (2.34)	9.15 (3.11)	16.45 (4.12)	6.42 (2.63)	10.67 (3.34)	19.59 (4.48)	7.24 (2.78)	10.44 (3.31)	15.09 (3.95)	3942	5132
T_6	27.20 (5.26)	33.93 (5.87)	55.10 (7.46)	8.14 (2.94)	12.40 (3.59)	23.54 (4.90)	4.78 (2.30)	6.23 (2.59)	8.45 (2.99)	3691	4821
T_7	26.60 (5.21)	32.90 (5.78)	54.20 (7.40)	5.80 (2.51)	10.08 (3.25)	17.44 (4.24)	4.14 (2.15)	5.39 (2.43)	7.84 (2.89)	4178	5431
T_8	5.00 (2.35)	9.27 (3.13)	16.90 (4.17)	6.50 (2.65)	10.70 (3.35)	19.65 (4.49)	4.10 (2.14)	5.36 (2.42)	7.79 (2.88)	4217	5448
T_9	27.47 (5.29)	34.37 (5.91)	55.74 (7.50)	8.32 (2.97)	12.75 (3.64)	23.92 (4.94)	7.34 (2.80)	10.54 (3.32)	15.22 (3.96)	3677	4802
T_{10}	26.95 (5.24)	33.27 (5.81)	54.70 (7.43)	6.39 (2.62)	10.55 (3.32)	19.34 (4.45)	4.64 (2.27)	6.18 (2.58)	8.28 (2.96)	3907	5107
S. Ed	**0.07**	**0.08**	**0.11**	**0.06**	**0.08**	**0.11**	**0.06**	**0.06**	**0.07**	**81.20**	**102.90**
CD (p = 0.05)	**0.21**	**0.24**	**0.31**	**0.18**	**0.22**	**0.31**	**0.18**	**0.18**	**0.19**	**171.92**	**217.87**

Table 2 Effect of different weed management practices on economics of maize

Treatment	Treatment Cost (₹/ha)	Cost of Cultivation (₹/ha)	Gross Income (₹/ha)	Net Income (₹/ha)	BCR
T_1	0	43113	34850	-8263	0.81
T_2	5000	48113	108806	60693	2.26
T_3	4330	47443	108495	61052	2.29
T_4	3230	46343	96244	49901	2.08
T_5	7010	50123	95798	45675	1.91
T_6	2710	45823	89714	43891	1.96
T_7	3080	46193	101525	55332	2.20
T_8	4120	47233	102439	55206	2.17
T_9	5390	48503	89373	40870	1.84
T_{10}	5250	48363	94968	46605	1.96

STUDIES ON SEED LONGEIVITY OF ORGANIC PELLETED SEEDS FOR VIABILITY AND STORAGE IN BLACKGRAM (*Vigna mungo* (*L*) HEPPER) VAR. VBN 5

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Abstract

An experiment was carried out to study the effect of seed storage quality of resultant seeds obtained from harvested seeds of organic pelleted blackgram variety VBN 5 using accelerated ageing chamber at Seed Science Laboratory, Faculty of Agriculture, and Annamalai University. Cleaned and graded seeds of blackgram imposed with the following treatments viz., Neem leaf powder @ 200 g per kg, Pungam leaf powder @ 200 g per kg, Prosopis leaf powder @ 200 g per kg, Nochi leaf powder @ 200 g per kg, Rhizobium biofertilizer @ 200 g per kg and Azospirillum biofertilizer @ 200 g per kg along with control were taken for the study. In the resultant seeds, Pungam leaf powder @ 200 g per kg pelleted seeds registered higher values for the characters viz., germination percentage (%), speed of germination, shoot length (cm), root length (cm), seedling length (cm), dry matter production (g seedling $^{-10}$), vigour index I and vigour index II. Pungam leaf powder pelleted seeds are also maintained with standard certification level of 75% after 5 days of accelerated ageing. This shows the storage potential of the black gram variety VBN 5 seeds.

Keywords: *Blackgram, accelerated ageing test, seed pelleting*

Introduction

Accelerated ageing is an excellent forecaster of seed viability and seed storability. Seed ageing is known to cause appreciable changes in viability and produce large number of changes in viability and produce large number of changes in qualitative and quantitative characters and can be used with case of inducing variability in peas (Purkar *et al.*, 1992).

Seed ageing and deterioration are said to be irreversible, inexorable, and inevitable processes, but rate of deterioration could be slowed down either by keeping the seed in good storage environment or by imposing certain seed treatment. In the developing countries like India, storage of seeds under controlled conditions is a costly affair. As an alternative, Basu (1993) suggested that to store the seeds after treating with certain invigouration treatments for enhanced storage potential of seeds. Other than invigouration treatments several methods are being adopted to prevent the qualitative loss during storage. One among them is treating the seeds with suitable plant products and storing in safe containers, besides maintaining proper sanitation of the storage place. In this regard halogens and fungicides are important. Although chemicals are very effective, but their residual toxicity can adversely affect both the animals and human beings besides affecting seed quality, since they are not readily degradable physically or biologically. The other alternative approach is treatment of seeds with plant products (botanicals), organics, etc., which are safe, economical, cheap and ecofriendly in nature. There are more than 56 plants whose different parts are used as natural seed protectants and they are more specific, less persistent without impairing the organoleptic properties of seeds.

Storage potential of lots can be evaluated by using the accelerated ageing (AA) technique. Results from six years study involving 16 lots of seeds showed that germination responses after AA are highly correlated with response in storage under a variety of conditions for periods up to

two years. AA responses were also closely associated with emergence potential of seeds, their growth and productivity of plants (Delouche and Baskin, 1973).

Accelerated ageing test showed that the ageing seed is characterized by the loss of germination, reduced speed of germination and poor seedling development (Lekic, 2003; Mosavi *et al.,* 2011). Maintenance of seed quality during storage period is important not only for successful crop production but also for maintaining the quality and integrity of the seed that are constant threat of genetic erosion (Barua *et al.,* 2009).

Materials and Methods

Harvested seeds of black gram variety VBN5 subjected to accelerated ageing chambers maintained at 95 ± 2 per cent relative humidity and a constant temperature of 40 ± 1°C (Delouche and Baskin, 1973) for a period of five days. The experiment was conducted at room temperature 26 ± 1°C in the Seed Technology Laboratory of Genetics and Plant Breeding.

Table 1. Certification standard for accelerated ageing in blackgram variety VBN-5

Accelerated ageing (days)	**Germination (%)**	**Minimum Indian certification standard (%)**
5	**60**	**75**

Observations were recorded for the following seedling characters

Germination (%)

Germination test was conducted with 3 × 100 seed from each treatment was carried out in sand media in a germination room maintained at a temperature of 25 ± 1°C and RH of 96 ± 2% with diffused light. The final count based on normal seedling was recorded on seventh day and the mean germination was recorded in percentage (ISTA, 1999).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

Speed of germination

Seeds were germinated in sterilized sand medium with three replicates of hundred seed each for all the treatments along with control. The number of seeds germinated was recorded daily up to the day for final count. From the number of seeds germinated on each counting day, the speed of germination was calculated by adopting the formula and expressed in number as (Magurie, 1962).

$$\text{Speed of germination} = \frac{X_1}{Y_1} + \frac{(X_2 - X_1)}{Y_2} + \ldots + \frac{X_n - (X_{n-1})}{Y_n}$$

X_1 - number of seed germinated at 1st count

X_2 - number of seed germinated at 2nd count

X_n - number of seed germinated at nth count

Y_1 - number of days from sowing to 1st count

Y_2 - number of days from sowing to 2nd count

Y_n - number of days from sowing to nth count

Root length (cm)

Ten normal seedlings were selected randomly in each treatment from all three replications on seventh day of germination test. The root length was measured from the tip of the primary root to base of hypocotyls with the help of a scale and the mean root length was expressed in centimeters.

Shoot length (cm)

Ten normal seedlings used for root length measurement, was also used for the measuring the shoot length. The shoot length was measured from the tip of the primary leaf to the base of the hypocotyls and the mean shoot length was expressed in centimeters.

Seedling length (cm)

Using the same ten normal seedlings, seedling length measurement was also recorded. Seedling length was measured from tip of the primary leaf to the tip primary root with the help of a scale and the mean seedling length was expressed in centimeters.

Dry matter production (g seedling^{-10})

Ten normal seedlings were used for growth measurements were placed in a paper cover and dried under shade for 24 h then kept in the hot air oven maintained at 85°C for 24 h. The dried seedlings were cooled in a desiccator for 30 minutes and the dry weight was recorded per ten seedlings and it was expressed in gram (Gupta *et al.,* 1993).

Vigour index I

The seedling vigour index I was calculated by adopting the method suggested by Abdul Baki and Anderson (1973) and expressed in number by using the formula.

Seedling vigour index I = Germination (%) × Seedling length (cm).

Vigour index II

The seedling vigour index II was calculated by adopting the method suggested by Abdul Baki and Anderson (1973) and expressed in number by using the formula.

Seedling vigour index II = Germination (%) × Dry matter production (g)

The experiment design followed always Completely Randomized Design with required replication for laboratory experiment, whenever necessary the values expressed in percentage were transferred into Arc Sin values before analysis. The critical difference (CD) was worked out at 5 per cent ($P = 0.05$) level and whenever 'f' value is non-significant, it is denoted by "NS".

Results and Discussion

Accelerated ageing for various days variable relative storability of cowpea seeds. The seeds that can resist changes in membrane are also able to maintain viability and quality (Bewley and Black, 1985). Increase ageing period had a suppressed effect of germination, seeds which are treated with Pungam leaf powder @ 200 g per kg with stand accelerated ageing up to 5 days (Table 2). The treated seeds maintain (60%) germination. Decrease in germination percentage related to reduction in seed vigour, accelerated ageing also decreased in seedling length and dry matter production. Similar results were reported in peanut (Sung and Jeng, 1994).

The possible reason of this reduction might be lowering biochemical activities to the seed ageing leads to damage effect on enzyme, that are necessary to convert reserve food embryo to usable form and ultimate production of normal seeds. In the present studies with progressive days for accelerated ageing show increased electrical conductivity, vigour and pH which indicated reduce vigour level in seeds.

Lipoxygenase is present in many unimbibed seeds, capable of catalyzing lipid peroxidation by using membrane phospholipids as substrate (Priestly and Leopold, 1983). The physiological role of this enzyme is not well understood and there is contradictory view about its role in the ageing process. Lipoxyzenase could promote slow lipid peroxidation, which is accompanied by the formation of activated oxygen, especially at levels of hydration that are far below those normally encountered in stored seeds.

From the present study, it was concluded that black gram seeds pelleted with Pungam leaf powder exhibited higher germination, speed of germination, shoot length, root length, seedling length, dry matter production, vigour index I and vigour index II under laboratory condition. Pungam leaf powder pelleted seeds are also maintained with standard certification level of 75% after 5 days of accelerated ageing. This shows the storage potential of the black gram variety VBN 5 seeds.

Table 2: Assessment of storage ability of organic pelleted seeds in blackgram var. VBN 5

Seedling length (cm)	Dry matter production (g seedling^{-10})	Vigour index I	Vigour index II
20.43	0.07	1178.11	4.23
22.73	0.11	1341.53	6.49
25.70	0.13	1713.40	8.90
24.11	0.12	1542.86	7.68
20.98	0.09	1230.78	5.08
22.25	0.10	1394.33	6.46
22.67	0.08	1354.07	5.11
22.61	0.10	1393.58	6.28
0.2507	0.0080	42.27	0.5126
0.5377	0.0171	90.67	1.0996

Treatment (T)	Germination (%)	Speed of germination	Shoot length (cm)	Root length (cm)
T_0	58 (49.41)	10.08	10.43	10.00
T_1	59 (50.19)	10.73	11.93	10.80
T_2	67 (54.74)	11.08	14.23	11.47
T_3	64 (53.14)	10.92	13.26	10.85
T_4	59 (49.99)	10.14	10.95	10.03
T_5	63 (52.35)	10.61	11.75	10.50
T_6	61 (51.55)	10.34	11.90	10.17
Mean	61 (51.63)	10.55	12.06	10.55
SE	1.5635 (0.9235)	0.1632	0.1586	0.2252
CD (P = 05)	3.3537 (1.9810)	0.3501	0.3401	0.4831

(Figures in parenthesis indicate arcsine transformed value)

T_0 – Control

T_1 – Neem leaf powder

T_2 – Pungam leaf powder

T_3 – Prosopis leaf powder

T_4 – Nochi leaf powder

T_5 – Rhizobium biofertilizer

T_6 – Azospirillum biofertilizer

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EFFECT OF SEAWEED EXTRACT AND HUMIC ACID ON GROWTH OF CLUSTER BEAN (*Cyamopsis tetragonoloba* (L.) TAUB.) Var. PUSA NAVBHAR

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Abstract

Cluster bean (Cyamopsis tetragonoloba (L.) Taub.) Commonly known as "Guar" is an essential legume crop largely raised under rainfed conditions in arid and semi-arid regions of Rajasthan, India during the Kharif season. The growth and yield of guar can be enhanced by several horticultural practices. One of them is the application of seaweed liquid fertilizers and humic acid. A field experiment was conducted to study the effect of seaweed extract and humic acid on growth, yield and post-harvest characters of cluster bean var. Pusa Navbahar. In field, the seaweed extract and humic acid were applied at 0.1, 0.2 and 0.3%in a randomized block design with seven treatments and three replicates. The results of the experiment revealed that the higher concentration of 0.3% seaweed extract and humic acid exhibited the dominant results in the plant height, number of leaves, stem diameter, leaf size, and dry matter production compared to other lower concentrations and control. The overall analysis indicated that the higher concentration of seaweed extract and humic acid performed well in all the characters of cluster bean compared to control.

Introduction

Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.) Commonly known as "Guar" is an essential legume crop largely raised under rainfed conditions in arid and semi-arid regions of Rajasthan, India during the Kharif season (Kumar, 2006). It is a drought tolerant and hardy crop (Kumar and Rodge, 2012). The roots penetrate to utilize possible moisture efficiently and therefore allow better scope for rainfed cropping. The plant also withstands even at moderate alkalinity and salinity conditions. It is cultivated for different purposes such as vegetable, fodder, gum and green manure. It gives nutritional concentrate for cattle and improves soil fertility by fixing a large amount of atmospheric nitrogen. It's a legume crop and can fix nitrogenupto 37-197 kg/ha (Undersander, 1991). The growth of guar can be enhanced by several horticultural practices. One of them is the application of seaweed liquid fertilizers and humic acid. The practical use of these organics plays an important role to perform a higher yield of guar. Seaweed fertilizers have been used as soil conditioning agents and fertilizers in ancient times also. Seaweed extract contains both major and micronutrients and these mixtures beneficial for seed germination and for increasing post-harvest shelf life. Seaweed extracts contain bioactive substances which act as plant growth-promoting substances namely auxin, cytokinins, vitamin and amino acid. Seaweed extracts help many crops by increasing nutrient availability, enhancing plant growth and yield, enhancing antioxidant properties, and improving tolerance to environmental stress. Humic acid is a primary

element of humic substances, which are the major organic constituents of soil. Humic substances are absorbed by the leaves, roots and transported to shoots, improving the growth and development of the whole plant. Humic acid consists of mineral nutrients such as calcium, magnesium, potassium, sodium, zinc, copper and iron. When humic acid is applied to plant, it can stimulate growth-promoting hormones viz., cytokinins, auxins and gibberellins (Chen et al., 1990). The bio-stimulants such as sea weed extract and humic acid would exert such effects in cluster bean. In this experiment, the objective is to study and determine the effect of seaweed extract and humic acid at various concentrations on growth of cluster bean var. Pusa Navbahar.

Materials and Methods

A field experiment was conducted to study the effect of seaweed extract and humic acid on growth of cluster bean var. Pusa Navbahar. The experiment was conducted from February to May in the year 2020-2021.The experiment was conducted at Kottucherry village, Karaikal district. The experimental location falls under coastal agro climatic zone and key description of climatic condition is dry and sub-humid in nature. The experiment consisting of seven treatments, carried out in Randomized Block Design with 3 replications each. The treatment details of the experiment are(T1) Seaweed extract foliar spray @ 0.1%, (T2) Seaweed extract foliar spray @ 0.2%, (T3) Seaweed extract foliar spray @ 0.3%, (T4) Humic acid foliar spray @ 0.1%, (T5) Humic acid foliar spray @ 0.2%, (T6) Humic acid foliar spray @ 0.3%, and (T7) Control-water spray. The plants were sprayed with the seaweed extract and humic acid individually three times at an interval of 15 days after sowing (DAS). The spray has been done 15, 30, and 45 days after sowing. The seed was sown in ridges and furrows at 2 cm deep at 45 ×30cm spacing. In order to assess the effect of different bio-stimulants on the growth of the crop, the following observations were recorded regularly. The observations recorded were plant height (cm), no of leaves, stem diameter (mm), leaf size (cm^2) and dry matter production (g)

Results and discussion

Growth characteristic

The foliar application of seaweed extract and humic acid significantly increased the growth attributes of the crop. On the 30th day, foliar spray of seaweed extract @0.3% (T3) recorded the highest plant height (42.67 cm) was followed by Humic acid @ 0.3% (39.0 cm).On the 45th day of observation, the treatment T6 - Humic acid @ 0.3% spray recorded the highest plant height (115.6 cm) which was followed by the application of Seaweed extract (T3) @ 0.3% (107.7cm).The number of leaves showed a significant difference among the treatments both on the 30th and 45th day of observation. On the 30th day of observation, humic acid @ 0.3% recorded a significantly higher number of leaves (15.00) and was followed by seaweed extract @ 0.3 % (14.67). On the 45th day of observation, humic acid at 0.3% significantly recorded the highest number of leaves (33.66). The foliar application of 0.3% of humic acid (T6) indicated improved stem diameter (mm) at 30 DAS and 45 DAS as compared to control. The application of humic acid at 0.3% (T_6) produced a higher length and width of leaves by 9.93cm and 7.13cm in 30 days. At 45 days 0.3% of seaweed extract (T_3) recorded higher length and width of leaves by 13.9 cm and 8.38 cm and secondly 0.3% of humic acid (T_6) recorded higher length and width of leaves by 13.86cm and 7.7cm. The foliar application of 0.3 % of humic acid on both 60 days and 90 days resulted in a significant increase in dry matter accumulation by 81.80 and 97.63 g respectively. The results showed that the use of seaweed extract and humic acid in higher concentrations promoted the growth characters of cluster bean. These two bio-stimulants are the most desirable alternatives to synthetic fertilizers. It keeps the proper stability of plant sources and sinks. Biostimulants are complex mixtures of compounds and occupy different modes of action associated with the growth

promotion of plants (Van Oosten *et al*., 2017). The reasons for better growth and development under these treatments might be due to macronutrient content in seaweed extracts. Macronutrients such as nitrogen, phosphorous and potassium play an important role which is very essential for the growth and development of the plant (Attememe, 2009).

The improvement in shoot characteristics might also be due to the presence of auxin in the seaweed extract which has an effective role in cell division and enlargement and leads to an increase the shoot growth, leaf size, and plant dry weight (Gollan and Wright, 2006). The function of humic acid in physiology occurs by promoting the enzymes and by increasing the efficacy of transfer of photosynthetic as well as increasing the division and elongation of cells (Fawzy *et al*., 2007) leading to increased growth, thus increased leaf mineral content. Spraying of plants with the humic acid could increase the photosynthesis (Bettoni *et al*., 2014). Nardi *et al*. (2002) also reported that humic acid enhanced the total protein content in plants and enhanced respiration and photosynthesis processes which in turn resulted in better growth promotion. Neri *et al*. (2002) reported that foliar application of humic acid had the positive effect on nutrient availability.

Table 1: EFFECT OF SEAWEED EXTRACT AND HUMIC ACID ON GROWTH OF CLUSTER BEAN (*Cyamopsis tetragonoloba* (L.) Taub.) var. PusaNavbhar

Treatments	**Plant height (cm)**		**Number of leaves**		**Stem diameter (mm)**		**Leaf size (cm^2)**				**Dry matter production (g)**	
							Leaf length (cm)		**Leaf width (cm)**			
	30 Days	**45 days**	**30 days**	**45 days**	**30 days**	**45 days**	**30 days**	**45 days**	**30 days**	**45 days**	**60 days**	**90 days**
T_1 - Sea weed extract @0.1%	33.17	101.37	12.67	30.00	0.43	1.20	8.60	12.53	5.33	6.20	78.63	93.43
T_2 - Sea weed extract @0.2%	36.00	100.90	13.00	32.67	0.38	1.37	8.80	13.70	5.80	7.53	79.87	95.37
T_3 - Sea weed extract @0.3%	42.67	107.77	14.67	33.00	0.50	1.77	9.67	13.90	6.77	8.38	81.37	96.73
T_4 - Humic acid @0.1%	35.83	103.37	13.00	30.00	0.37	1.23	9.40	12.60	6.27	6.87	78.97	92.90
T_5 – Humic acid @0.2%	34.17	106.70	13.33	31.67	0.47	1.40	9.53	12.27	6.63	7.10	81.17	94.23
T_6 – Humic acid @0.3%	39.00	115.60	15.00	33.67	0.58	1.80	9.93	13.87	7.13	7.70	81.80	97.63
T_7- Control	31.00	99.37	12.33	29.00	0.33	1.12	8.17	12.10	5.13	6.10	75.13	88.30
SEm	1.485	2.695	0.457	0.649	0.041	0.096	0.342	0.390	0.295	0.158	1.060	0.876
SEd	2.101	3.811	0.647	0.917	0.058	0.135	0.485	0.552	0.415	0.224	1.499	1.239
CD (0.05)	4.628	8.395	1.424	2.021	16.20	11.73	1.068	1.216	0.918	0.494	1.704	2.703

Conclusion

This study concluded that foliar application of seaweed extract at 0.3% (T3) which was equally effective to humic acid at 0.3% (T6) significantly enhanced the plant height (cm) on 30th and 45th days after sowing (DAS), number of leaves on 30 and 45 DAS, stem diameter (mm), leaf size (cm) on 30 and 45 DAS, and dry matter production (g) on 60 and 90 DAS. Enhancement in yield parameters of the number of pods per plant, pod length (cm), pod yield per plant (g), total yield per hectare (t/ha), numbers of picking and 100 pod weight (g) were also noted. From the overall analysis, the higher concentration of seaweed extract and humic acid performed well in all the characters of cluster bean compared to control. Economically, the foliar spray of humic acid and seaweed extract exhibits increased yield, and quality of produces and they are cost- wise cheap, and affordable to farmers.

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ANALYZE OF WEED DENSITY AND WEED BIOMASS IN DIFFERENT RICE ESTABLISHMENT METHOD

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Abstract

Higher cost and demand of labours and shrinking availability of water have forced the farmers to look for an alternative method of rice cultivation as a substitute to existing tranditional method of rice transplanting. Direct dry method of rice transplanting is the alternative method of rice establishment and water saving method but weeds is the most important problem in direct dry method of rice establishment. Against this backdrop, a field study was undertaken during Kuruvai 2021 to evaluate the effect of crop establishment methods and weed management practices on rice and its associated weed flora. The result demonstrated that grain yield obtained under SRI method were significantly superior to other method of rice establishment and it was on par with mechanical method of rice transplanting. Weed density followed the order of direct dry seeded rice cultivation > Drum sowing > conventional transplanting > mechanical transplanting > SRI rice transplanting. With the advancement in age of the crop, sedges dominated in direct method of rice cultivation, broad leaf weeds dominated in transplanting method of rice cultivation. All the herbicides reduce the weed density significantly as compared to weedy check. Maximum density of weeds was observed in weedy check and lowest weed density were observed in PE followed by POE.

Key words: *Weed density, weed dry matter production, grain yield*

Introduction

Rice is the major food crop for most of the population, particularly in Asian countries. In Asia, India is second major rice producer after china, with the contribution of 21.5% to the world rice production. Rice cultivation methods have been changing from time to time in response to technology developments, labour and water availability and increased cost of production and higher cropping intensity. In India, rice is mainly cultivated through conventional method of transplanting, however, alternative to this, direct seeding has been practices successfully in the past two decades with few manipulations, depending on the agro-climatic conditions. Since then, several sowing and crop establishment methods have evolved, such as water seeding, dry direct seeding and wet seeding using dry or pre-germinated seeds and these have offered promise in water scare and labour shortage scenarios. However, in direct seeding practices the emerging seedlings are having very slower initial growth habits (Yadav *et al.*, 2017). Compared to transplanted rice cultivation or the direct dry seeded and wet seeded cultivation the menace due to weeds are higher as the weeds emerges before or simultaneously

with the crop emergence and thus it inturn brings down the final grain yield. Hence, to evade this problem, alternate method of rice establishment need is to be evolved, assessed and introduced to achieve sustainable crop productivity.

The System Rice Intensification (SRI), a novel method of transplanting rice cultivation, where in the maximum exploitation of the rice genetic potential of the rice cultivars could be attributed by providing an congenial environment for appropriate crop growth to enhance crop productivity and monetary returns. Besides, it also prevents deterioration of soil health altogether with minimal water application and seed rate, etc. (Gayatree Mishra *et al*., 2018). In India, an economic loss of USD 11 billion has been found to be inflicted by weeds alone in major crops, out of which the share of rice is 21.4% and 13.8% in direct seeded and transplanted rice, respectively. Practice to control weed menace, though manual an chemical methods are common. However, manual weeding is a laborious and back breaking process. Chemical weed control, which involves application of different pre- and post-emergence broad spectrum herbicides, had been advocated in rice. Over the years chemical weed control had gained importance in controlling weeds, owing to its advantage over other method of weed control, like ease in such as pretilachlor, bensulfuron-methyl, phyrazosulfuron-ethyl etc and post emergence herbicides such as bispyribac-sodium, penoxsulam, fenoxaprop, aimsulfuron are recommended and usedin direct seeded and transplanted rice in Inida. In this background, a field experiment at experimental farm, faculty of agriculture, Annamalai University was conducted to evaluate the response of rice and its associated weed flora to crop establishment methods and weed management practices under clay soil condition.

Materials and methods

A field experiment was conducted at Experimental Farm, Department of Agronomy, and Annamalai University during *kuruvai* seasons of 2019-2020 and 2020-2021 to study the effect of different rice establishment methods and weed management practices on establishment percentage and weed population of rice. The study area has mean annual rainfall of about 1500 mm, majority of which was received during North East Monsoon. The climate of the region is characterized by a tropical climate with a hot dry summer (March-May), and extended wet period from November to February. The soil is clayey loam with a pH of 7.3.

In this study the performance of different crop establishment and weed management practices was evaluated. The experiments were conducted in split plot design with three replications. The treatment comprised of five establishment method as main treatments *viz.*, (M_1)- Direct dry seeded rice, (M_2)- Drum seeded rice, (M_3)- SRI transplanting, (M_4)- Machine transplanting, (M_5)- Conventional transplanting and six weed management practices as sub treatments *viz.*, (S_1)- Unweeded control, (S_2)- Two hand weeding on 20 and 40 DAT/ DAS, (S_3)- Pre-emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR(pre-mix) @ 10 kg ha^{-1} on 3 DAT/ 7 DAS + hand weeding on 40 DAT/DAS, (S_4)- Pre-emergence application of pretilachlor 6% + pyrazosulfuron-ethyl 0.15 % GR (pre-mix)@ 10 kg ha^{-1} on 3 DAT/ 7 DAS + hand weeding on 40 DAT/DAS, (S_5)- Pre-emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR (pre-mix) @ 10 kg ha^{-1} on 3 DAT/ 7 DAS + Post-emergence application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 15 DAT/DAS and (S_6)- Pre-emergence application of pretilachlor 6% + pyrazosulfuron-ethyl 0.15 % GR (pre-mix)@ 10 kg ha^{-1} on 3 DAT/ 7 DAS + Post-emergence application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 15 DAT/DAS. The variety taken for experiment was CO 51 during *kuruvai* 2019-2020. The plot size of experiment was 5 × 4 m. A fertilizer schedule of 120 : 40:

40 NPK kg ha^{-1} was adopted as the common practice for the experiment. Full dose of phosphorous and half dose of nitrogen and potassium were applied basally. The remaining half dose of nitrogen and potassium were applied into two splits during maximum tillering and panicle primordium initiation (PPI) stage. Nitrogen, phosphorous and potassium were supplied through urea, single super phosphate, and muriate of potash respectively. As per the treatment schedule required quantity of herbicides was sprayed and for the treatment S_2 hand weeding was done at 20 and 40 DAT/DAS. The pre-emergence and post-emergence herbicides were sprayed with high volume knapsack sprayer fitted with flood jet nozzle using 500 liters of water ha^{-1}. All the pre-emergence herbicides were sprayed on 3 DAT/ 7 DAS and post-emergence herbicides were sprayed on 15 DAT/DAS respectively.

The field was ploughed to fine tilth and made to puddled condition. Paddy seeds soaked in water for 24 hours were stored in gunny bags for 24 hours. Pre-germinated seeds were filled in seeding drums and sown in the field within the demarked plots. SRI transplanting was done in levelled field under puddled soil condition. For transplanting, a spacing of 25 x 25 cm between inter and intra row and were adopted in both the cropping seasons. Single rice seedlings of 14 days old were used for transplanting. Mechanical transplanting was done in well puddled soil. Mat nursery which was already prepared is used for transplanting with self-propelled paddy transplanter, which could plant eight rows in one pass with the spacing of 20 cm × 15 cm during both the years of field experimentation. Under conventional method the row transplanting twenty five day old seedlings were transplanted with a spacing of 15 cm × 10 cm in both the years of study. The seedlings were planted in puddled conditions @ two seedlings hill^{-1}. Care was taken to fill the gaps on 10th days after transplanting with seedlings of same age. Five sample plots of 1.0 m^2 area in each sub plot treatments in all the replications were peg marked and the established rice seedlings in each sample plots were counted on the day of gap filling operation from which the mean germination were arrived as against the number of seeds/seedlings sown on 15 DAT/DAS to work out the percentage of crop establishment.

The total number of weeds were recorded from the four quadrants of 0.25 m^{-2} area placed at random in each of the net plot area and computed to total weeds m^{-2}. Prior to transplanting the weed species present in the unweeded plots were identified and grouped in to grasses, sedges and broad leaved weeds. Data on weed population and weed dry matter production showed high variation and hence they were subjected to square root transformation $\sqrt{(x + 0.5)}$ and analyzed.

Result and Discussion

Irrespective of the cropping season and the stages of crop growth, rice establishment methods and weed management practices exerted significant influence on total weed population.

Among the rice establishment methods evaluated, SRI transplanting (M_3) of rice registered lower weed density and lower weed biomass during *Kuruvai* 2021 and were comparable with the mechanical transplanting (M_4) of rice. On other hand, the highest weed density and highest weed biomass during *Kuruvai* 2021 were recorded under direct dry seeding of rice (M_1) crop. Regarding the weed management practices test verified, the lowest total weed density and weed biomass were resulted with the pre-emergence (PE) application of premixed pretilachlor 6% + bensulfuron methyl 0.6% GR @ 10 kg ha^{-1} on 3 DAT/ 7 DAS + post-

emergence (PoE) application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 20 DAT/DAS (S_5). However, it was comparable with the PE application of premixed pretilachlor 6% pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} on 3 DAT / 7 DAS + PoE application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 20 DAT/DAS (S_6) at all the stages of crop growth. Regardless the cropping seasons and stages of crop growth the un-weeded control (S_1) resulted with the highest population of total weeds. Although only single seedlings $hill^{-1}$ are being transplanted, the wider inter and intra row spacings of 25 cm would facilitates maximum germination of weed at initial stage of crop growth. However, the practice of cono weeding adopted under the SRI system on 10^{th} day after transplanting effectively *in situ* incorporated the germinated weeds in soil profile Chakraborty *et al.,* (2017).

Further, the weed germinated at later stages were also periodically incorporated *in situ* with the successive cono weeding operations on 20, 30 and 40 DAT, and it might be the probable reason for lowest population of weeds, nutrient removal and the dry matter accumulation with this treatment. Similar type inferences were also documented by Ayyadurai and Thiyagarajan (2020). Regarding direct dry seeding of rice (M_1) treatment and also the direct seeding of germinated wet seeds with drum seeder (M_2) treatment the beneficial effects of transplanting shock like vigour crop growth resulted through the triggered productivity of growth promoting hormones and the enzymes could not be realised. Moreover, the chance of uneven depth of sowing under these treatments might have also declined the germination and establishment, which is evident from the numerically reduced values of establishment per cent with these treatments in both the cropping seasons. Moreover, the above situations would also facilitates weeds to putforth high competition with the crop to register enhanced population, nutrient uptake and weed dry matter production. The experimental results of Abu Yamah (2002) are also in accordance with the above findings.

Conclusion

From the study, it was concluded that SRI transplanting and mechanical transplanting were registered lowest density of weeds and their biomass. The highest weed density and weed biomass per unit area was recorded in direct dry seeded rice cultivation among the weed management practices sequential application pre-emergence followed by post-emergence herbicidal application reduce the weed density and weed biomass per unit area. Over all the efficacy of PE was better in reducing weed density and weed biomass across the crop establishment methods.

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Table 1. Effect of different establishment methods and weed management Practices on total weeds density and weed biomass during 2021 cropping season.

Treatment	Total weed density (No. m^{-2}) 60DAT/DAS	Weed biomass (kg ha^{-1}) 60DAT/DAS
Establishment methods		
M_1	10.04 (100.93)	21.23 (450.13)
M_2	9.18 (84.37)	19.31 (372.38)
M_3	7.71 (59.07)	15.36 (190.59)
M_4	8.46 (71.16)	18.20 (33.60)
M_5	8.60 (73.62)	18.32 (335.39)
SEd	0.38	1.01
CD (p=0.05)	0.82	0.48
Weed management practices		
S_1	13.89 (192.64)	18.37 (337.09)
S_2	7.86 (61.35)	8.11 (65.43)
S_3	7.32 (53.16)	7.57 (56.94)
S_4	8.47 (71.27)	8.89 (78.69)
S_5	6.65 (42.35)	6.94 (47.69)
S_6	8.60 (73.62)	7.02 (48.84)
SEd	0.38	0.63
CD (p=0.05)	0.82	0.29

EVALUATION OF ORGANIC EXTRACTS AGAINST DIAMOND BACK MOTH, *Plutella xylostella* (L.) ON CAULIFLOWER

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Abstract

An experiment was conducted during Rabi 2020-21 at Parinche, Pune to study the efficacy of organic extracts at different incubation periods with FRBD design to manage Plutella xylostell (L). on cauliflower. The bio-efficacy study against the diamond back moth indicated that among all organic extracts, 30 days incubated PDKV organic formulation 10% recorded lowest larval population of DBM at 3, 7, 10 & 14 days after spray with 3.14, 1.74, 2.39 & 2.83 larvae/plant. It was followed by treatment of 30 days incubated PDKV botanical extract 10% and 30 days incubated Triparni extract 10%. Whereas, 15 days & 7 days incubated organic extracts proved relatively less effective against diamond back moth.

Keywords*: Bio-efficacy, Cauliflower, Indigenous products, Organic extracts, Plutella xylostella*

Introduction

The diamondback moth (*Plutella xylostella* L.) is a globally important pest, causing serious yield losses to crucifers. In India, diamondback moth has national importance on cabbage and cauliflower as it causes 50-80% annual loss in the marketable yield[4]. For over three decades, the insecticide market has been dominated by organophosphates, carbamates and synthetic pyrethroids. *P. xylostella* showed resistance to spinosad, chlorantraniliprole, deltamethrin, chlorpyrifos & chlorfenapyr[13,21]. Only 1% of the global insecticide market is occupied by the two bio-insecticides (*Bt* based products) and insecticides of plant origin (pyrethrum and neem-based products)[9]. Toxicity and development of resistance issues have limited the use of these synthetic insecticides. Therefore, it is desirable to develop alternative methods for pest management based on botanical pesticides, which are safe to both humans and the environment[24]. Botanical pesticides are known as natural insecticides and are commonly used to protect crop plants and the environment from pesticides pollution in agroecosystem. They are relatively harmless to non-target organisms. Also, the possibility of insect developing resistance to natural plant products is less. In the present investigation, three organic extracts of some indigenous products (used by the traditional growers) alongwith different incubation periods were evaluated for their efficacy against diamond back moth, *P. Xylostella* on cauliflower.

Materials and Methods

The field experiment was conducted in a Factorial Randomized Block Design (FRBD) statistical design with four organic extracts along with water sprayed control in factor A and three incubation periods of organic extracts in factor B with three replications. The net area for the experiment was 1080 sq.m. There were a total of 36 plots of 5.20 m x 4.40 m. Interspacing between plots was 0.6 m. Twenty six days old seedlings of cauliflower variety Tetris (Syngenta) grown in nursery were transplanted with a spacing of 60 cm between rows and 45 cm within a plants on Dec 06, 2020. Irrigation was given immediately after transplanting of seedlings. Agronomic practices were done to raise healthy crop according to recommendations. At the time of appearance of the pest, the crop was sprayed with the treatments as mentioned in Table 1. Total two sprayings each at fortnight interval have been done. In control plots, water spray was given. For each spraying,

600 L of spray solution per hectare was used and sprayed with the help of the electric energy compression knapsack sprayer.

Extraction of botanicals

The fresh leaves of plants were collected and washed thoroughly then were dried under shade for few minutes. The plant material was ground to fine powder with the help of electric grinder then the plant material and freshly collected cow dung and cow urine was soaked in distilled water at room temperature as per the incubation period (i.e. 7, 15, and 30 days). The ratio of plant material and water was 1:10 (w:v), which was essential to make 10% solutions. The plant materials were then squeezed after incubation periods and the solution was doubled filtered through a fine muslin cloth which was and stored in separate bottles with labels.

Method of recording observation

For recording the *P. xylostela* population, 10 plants per net plot was selected randomly and larval count was made. A pre-count of diamond back moth population was made in each net plot before 1 day of spraying and post treatment counts were taken after 3,7 and 10 days of each treatment spray.

Statistical analysis

Factorial Randomized block design (FRBD) was used to conduct the experiment and the data obtained were converted to appropriate transformations and were subjected to statistical analysis to test the level of significance (Gomez and Gomez, 1984)[8].

Table 1. Plant parts and quantity used in present investigation.

Sr. No.	Treatment	Plant material		Quantity g/10 liter water
		Common name	Scientific name	
1.	Triparni Extract	Papaya leaves	Carica papaya	200
		Castor leaves	Racinus communis	200
		Rui leaves	Calotropis gigantea	200
2.	PDKV Organic formulation	Tobacco leaves	Nicotina tabaccum	300
		Parthenium leaves	Parthenium hysterophorus	150
		Kanher leaves	Nerium olender	100
		Gulvel leaves	Tinospora cardiofolia	40
		Asafoetida	Ferula asafoetida	10
3.	PDKV Botanical extract	Shitafal seeds	Annona squamosa	300
		Karanj Seeds	Pongamia pinnata	250
		Ipomea leaves	Ipomea carnea	50

Result and Discussion

Population of diamond back moth larvae1 day before and 3, 7, 10 and 14 days after spraying are presented in the Table 2 , 3 , 4 , 5 & 6. The incidence of DBM prior to spraying did not vary significantly among the treatments, including the untreated plots, indicating uniform distribution of DBM in the field.

Effect of organic extracts against DBM on cauliflower at 3 days after spraying

The results indicated that cumulative mean data on organic extracts with different incubation periods at three days after spray against diamond back moth was found significant. Among the treatments, 30 days incubated PDKV organic formulation was significantly more effective in recording minimum population of DBM (3.14 larvae/plant). However, this treatment was found at par with 30 days incubated PDKV botanical extract (3.38 larvae/plant), 30 days incubated Triparni extract (3.52 larvae/plant) and PDKV organic formulation with 15 days incubation (3.89 larvae/plant). The remaining treatments *viz*., 15 days incubated PDKV botanical extract (4.20), 7 days incubated PDKV organic formulation (4.52), 15 days incubated Triparni extract (4.60), 7 days incubated PDKV botanical extract (4.82) and 7 days incubated Triparni extract (4.84) showed their efficacy in descending order against DBM. Whereas, the maximum population of DBM was recorded in control plot (6.79 larvae/plant).

Effect of organic extracts against DBM on cauliflower at 7 days after spraying

The cumulative mean data at 7 days after spray indicated that among all the interactions the 30 days incubated PDKV organic formulation recorded significantly minimum population of DBM (1.74 larvae/plant). However, this treatment was found at par with 30 days incubated PDKV botanical extract and 30 days incubated Triparni extract with 2.15 and 2.37 larvae/plant, respectively. These were followed by treatment of 15 days incubated PDKV organic formulation (2.92),15 days incubated PDKV botanical extract (3.48), 7 days incubated PDKV organic formulation (3.67), 15 days incubated Triparni extract (3.70), 7 days incubated Triparni extract (3.88) and 7 days incubated PDKV botanical extract (3.95) found at par with each other. Whereas, the control plot recorded maximum population of 6.95 larvae/plant.

Effect of organic extracts against DBM on cauliflower at 10 days after spraying

The cumulative mean data on interaction effect of organic extracts with different incubation periods against diamond back moth at ten days after spray indicated that among all the treatments 30 days incubated PDKV organic formulation recorded minimum population of DBM (2.39 larvae/plant). However, this treatment was found at par with 30 days incubated PDKV botanical extract and 30 days incubated Triparni extract with the population of 2.84 and 3.05 larvae/plant, respectively. The next treatments in order of efficacy were *viz.*, 15 days incubated PDKV organic formulation (3.82), 15 days incubated PDKV botanical extract (4.03), 15 days incubated Triparni extract (4.15), 7 days incubated PDKV organic formulation (4.25), 7 days incubated Triparni extract (4.40) and 7 days incubated PDKV botanical extract (4.48). Whereas, maximum larval population of DBM was noticed in untreated control plot (7.10 larvae/plant).

The present findings pertaining to efficacy of organic extracts with different incubation periods against diamond back moth on cauliflower finds support in the research carried out by earlier workers. The plant extracts which have been discussed are used in present studies as one of the components of different organic extracts treatments. Tobacco extract has the highest efficacy (95.39%) after chemical control and least efficacy was resulted by Akk (*Calotropis procera*) extract (80.98%) against diamond back moth[28] similar results were obtained in present investigation. Botanical extracts are very useful for the control of pests if applied at initial stage of infestation, as botanical extracts have edge of less hazardous for human health, environment friendly, and safe for natural enemies[22]. Aqueous extracts of *Parthenium* recorded provided

60% mortality of first instar of *S. litura*[3]. Whereas, asafoetida based solution was reported as effective against the larvae of *Helicoverpa* and *Melanagromyza*[27]. Four weeks incubated *Ipomea carnea* aqueous extracts was effective in reducing the larval population of *Helicoverpa armigera* and *Spodoptera litura* resulted in higher groundnut production. Whereas, cost benefit ratio was higher (1:1.8) with use of *Pongiamia pinnata* extract[23].

The aqueous custard apple seed extract was reported effective against diamondback moth (*Plutella xylostella*) on cabbage[12]. The insecticidal activity of custard apple seeds is due to the chemical compound known as acetogenins which is toxic to insects[18]. Combined treatment of pongamia 10%, aloe *(Aloe barbadensis)* 5%, NSKE 10% with cow urine (30%) inflicted the highest larval mortality of *H. armigera.* (78.88%). Whereas, cow urine and cow dung were ineffective as they were unable to inflict any mortality even after lapse of maximum post application period of 96 hrs[6]. *Pongamia pinnata* mature seed extract 5.0% exhibited more than 50% *H. armigera* first instar larval mortality and more than 65% third instar larval feeding deterrence[20]. Twenty days fermented *Tinosphora rumphi* plant extracts were as effective and comparable to the synthetic pesticide in terms of average number of whiteflies reduced after spraying[5]. The efficacy of *Carica papaya* is attributed to its leaf sap which contains groups of cysteine protease enzymes such as papain and produces alkaloid group compounds, terpenoids, flavonoids, and non-protein amino acids that are highly toxic to plant sucking insect pests such as aphids, spotted bollworms, and whiteflies[30].

Conclusions

While considering the efficacy of organic extracts against diamond back moth population reduction, 30 days incubated PDKV organic formulation showed better results which was closely followed by 30 days incubated PDKV botanical extract and 30 days incubated Triparni extract days incubated organic extracts over other treatments. These initial findings on bio-efficacy are useful to find out the potentiality of plant products. Further research might be conducted to promote development of new commercial indigenous plant products suitable for controlling *P. xylostela* and other pests of cauliflower.

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Table 2: Larval population of diamond back moth 24hrs before first spray

Treatments	DBM larvae / plant: Incubation period of extracts (in days) 7	15	30	Factor 'A' (Extract)
Triparni Extract 10%	5.07 (2.25)	5.23 (2.29)	5.13 (2.26)	5.14 (2.27)
PDKV Organic Formulation 10%	5.17 (2.27)	5.03 (2.24)	4.93 (2.21)	5.04 (2.24)
PDKV Botanical Extract 10%	5.07 (2.25)	4.93 (2.21)	5.03 (2.24)	5.01 (2.23)
Control (Water spray)	5.20 (2.27)	5.27 (2.29)	5.10 (2.25)	5.19 (2.27)
Factor 'B' (Incubation Period)	5.13 (2.26)	5.12 (2.26)	5.05 (2.24)	

	Factor 'A'	Factor 'B'	Interaction (A×B)
'F' test	NS	NS	NS
SE(m)±	0.06	0.05	0.11
CD (p=0.05)	-	-	-

(Note: Figures in parentheses are corresponding square root transformation values)

Table 3: Cumulative efficacy of organic extracts with different incubation periods against diamond back moth on cauliflower at three days after spray

Treatments	DBM larvae / plant: Incubation period of extracts (in days) 7	15	30	Factor 'A' (Extract)
Triparni Extract 10%	4.84 (2.20)	4.60 (2.14)	3.52 (1.88)	4.32 (2.07)
PDKV Organic Formulation 10%	4.52 (2.13)	3.89 (1.97)	3.14 (1.77)	3.85 (1.96)
PDKV Botanical Extract 10%	4.82 (2.19)	4.20 (2.04)	3.38 (1.83)	4.13 (2.03)
Control (water spray)	6.15 (2.47)	6.57 (2.56)	6.79 (2.61)	6.50 (2.54)
Factor 'B' (Incubation Period)	5.08 (2.25)	4.82 (2.19)	4.21 (2.05)	

	Factor 'A'	Factor 'B'	Interaction (A×B)
'F' test	Sig	Sig	Sig
SE(m)±	0.05	0.04	0.08
CD (p=0.05)	0.14	0.12	0.24

(Note: Figures in parentheses are corresponding square root transformation values)

Table 3: Cumulative efficacy of organic extracts with different incubation periods against diamond back moth on cauliflower at three days after spray

Treatments	DBM larvae / plant Incubation period of extracts (in days)			Factor 'A' (Extract)
	7	15	30	
Triparni Extract 10%	4.84 (2.20)	4.60 (2.14)	3.52 (1.88)	4.32 (2.07)
PDKV Organic Formulation 10%	4.52 (2.13)	3.89 (1.97)	3.14 (1.77)	3.85 (1.96)
PDKV Botanical Extract 10%	4.82 (2.19)	4.20 (2.04)	3.38 (1.83)	4.13 (2.03)
Control (water spray)	6.15 (2.47)	6.57 (2.56)	6.79 (2.61)	6.50 (2.54)
Factor 'B' (Incubation Period)	5.08 (2.25)	4.82 (2.19)	4.21 (2.05)	

	Factor 'A'	Factor 'B'	Interaction (A×B)
'F' test	Sig	Sig	Sig
SE(m)±	0.05	0.04	0.08
CD (p=0.05)	0.14	0.12	0.24

(Note: Figures in parentheses are corresponding square root transformation values)

Table 5: Cumulative efficacy of organic extracts with different incubation periods against diamond back moth on cauliflower at ten days after spray

Treatments	DBM larvae / plant Incubation period of extracts (in days)			Factor 'A' (Extract)
	7	15	30	
Triparni Extract 10%	4.40 (2.10)	4.15 (2.04)	3.05 (1.75)	3.87 (1.97)
PDKV Organic Formulation 10%	4.25 (2.06)	3.82 (1.95)	2.39 (1.55)	3.49 (1.87)
PDKV Botanical Extract 10%	4.48 (2.12)	4.03 (2.00)	2.84 (1.69)	3.78 (1.94)
Control (water spray)	6.83 (2.61)	6.95 (2.63)	7.10 (2.66)	6.96 (2.64)
Factor 'B' (Incubation Period)	4.99 (2.23)	4.74 (2.18)	3.85 (1.96)	

	Factor 'A'	Factor 'B'	Interaction (A×B)
'F' test	Sig	Sig	Sig
SE(m)±	0.05	0.04	0.08
CD (p=0.05)	0.14	0.12	0.24

(Note: Figures in parentheses are corresponding

IMPACT OF PRESOWING SEED TREATMENT ON CROP GROWTH, SEED YIELD AND SEED QUALITY IN RICE

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Abstract

The field experiment was carried to evaluate the role of pre-sowing seed treatment on crop growth, seed yield and seed quality in rice. The fresh seeds were primed with different priming chemicals and pelleted with bio-inoculants viz., 1% KNO_3 + Azospirillum @ 600g/ha, 1% $CaCl_2$ + Azospirillum @ 600g/ha, 1% KCl + Azospirillum @ 600g/ha, 1% $ZnSO_4$ + Azospirillum @ 600g/ha, 1% KNO_3 + Pseudomonas fluorescens @ 10g/kg, 1% $CaCl_2$ + Pseudomonas fluorescens @ 10g/kg, 1% KCl + Pseudomonas fluorescens @ 10g/kg, 1% $ZnSO_4$ + Pseudomonas fluorescens @ 10g/kg, and Azospirillum @ 600g/ha + Pseudomonas fluorescens @ 10g/kg. The results of the field experiment revealed that seed primed with $CaCl_2$ @ 1% followed by pelleted with azospirillum @ 600g/ha recorded higher values for the growth parameters and yield parameters. The resultant seeds from the same treatment registered the best seed quality parameters. From the study, it was concluded that rice seeds primed with $CaCl_2$ @ 1% then pelleted with azospirillum @ 600g/ha performed well for seed quality characters under lab condition as well as yield contributing characters under field condition when compared to other treatments.

***Keywords**: Rice, seed yield, seed priming, seed pelleting, Azospirillum*

Introduction

Seed plays a vital role in sustained growth of agriculture. The continuous supply of good quality seeds to seed producers, to produce genetically pure seed and to preserve the quality of seeds with all inputs and management practices are the two most important aspects in the seed programme. No agricultural practice can boost a crop beyond the limits set by the seeds. Any achievement in the crop improvement can be propagated and established in field only through good quality seeds. Hence, the production of high-quality seed is necessary and important to the agricultural industry. Modern agriculture with its incline for precision farming demands that each seed sown must germinate and establish into a vigorous plant.

Successful seed production depends on numerous techniques that aim at enhanced productivity of quality seed as the seed production is influenced by seed, pre- and post-harvest crop management techniques (Copeland and McDonald, 1985). Quality seed plays seminal role in augmenting agricultural productivity as well as production. Only by using quality seeds, productivity can be enhanced to the tune of 15-20%. Seed quality may also differ between cultivars, among and within seed lots. One of the improved seed production packages to increase the production and yield was adopting the proper pre-sowing seed management practices. Seed technology research has donated precise technologies as an answer to specific problem in agriculture.

Pre-sowing seed treatments such as seed priming and seed pelleting could improve the seed germination and seedling vigour particularly under unfavorable environment conditions. Seed priming is an easy, low cost and low risk method for improving growth and development of plants especially under adverse environmental conditions. Seed priming has been developed as an indispensable method to produce tolerant plants against various stresses. Seed priming is a

controlled hydration technique that triggers the normal metabolic processes during early phase of germination before radicle protrusion. The beneficial effects of seed priming include faster emergence, better stands, and lower incidence of re-sowing, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield.

Seed pelleting is one of the pre-sowing seed treatments that have widely applied for many crops around the world (Dmytryk*et al*., 2015). Inoculation may be defined as the process of adding effective plant growth promoting microorganism to the host plant seed before planting. The purpose of inoculation is to make sure that there is enough of the correct type of microorganism present in the soil so that a successful crop-organism symbiosis is established. Bio-fertilizer play an important role in supplementing nutrients to the plants and restoring the soil fertility, regenerates soil productivity leading to the sustainable farming ((Kumar *et al.,* 2013; Patel *et al.,* 2014). With this background, field trial was undertaken to evaluate the effect of pre-sowing seed treatment on crop growth, seed yield and seed quality in rice.

Materials and Method

A freshly harvested, genetically and physically pure seed of rice cv. ASD 16 was collected from Tamil Nadu Rice Research Institute (TRRI), Aduthurai, served as a basic material for priming and pelleting process. The fresh seeds were primed with different priming chemicals and primed seeds were then pelleted with an addition of adhesive (10% Maida solution) and bio-inoculants to the seeds and left for 3 hours. The seeds are dried under shade followed by sun drying for 2-3 hours. To evaluate the performance of pre sowing seed treatment, a field experiment was carried out at Plant Breeding Farm, Faculty of Agriculture, Annamalai University during the year 2020 - 2021.The trial was conducted in a Randomized Block Design and replicated thrice.

Pre-sowing seed treatments details

T_0 - Control

T_1– 1% KNO_3 + *Azospirillum* @ 600g/ha

T_2 – 1% $CaCl_2$ + *Azospirillum* @ 600g/ha

T_3 – 1% KCl + *Azospirillum* @ 600g/ha

T_4 – 1% $ZnSO_4$ + *Azospirillum* @ 600g/ha

T_5 - 1% KNO_3 + *Pseudomonas fluorescens* @ 10g/kg

T_6 - 1% $CaCl_2$ + *Pseudomonas fluorescens* @ 10g/kg

T_7 - 1% KCl + *Pseudomonas fluorescens* @ 10g/kg

T_8 - 1% $ZnSO_4$ + *Pseudomonas fluorescens* @ 10g/kg

T_9- *Azospirillum* @ 600g/ha + *Pseudomonas fluorescens* @ 10g/kg

The treated seeds were sown in raised nursery bed. Twenty days old seedlings were transplanted to the main field at the rate of one seedling per hill with the spacing of 15 cm between rows and 10 cm within plants. Recommended cultural practices were followed. During the growth period, five randomly selected plants were tagged in each treatment replication wise, and the observations related to growth and yield attributing characters were recorded under the field condition. After harvest, the resultant seeds were pooled, cleaned, dried to a moisture content of 12% and graded for uniformity. The randomly selected samples of seed from each treatment were evaluated for their seed quality characters. The data was analyzed statistically adopting the procedure described by Panse and Sukhatme (1985).

Results and Discussion

In the present investigation, among the treatments, it was revealed that pre-sowing seed treatment (seed primed with $CaCl_2$ @ 1% followed by pelleted with *azospirillum* 600g/ha) recorded higher values for the growth traits viz. days to first flowering (70 DAS), days to 50 per cent flowering (73 DAS), plant height (80.20cm), panicle length (23.50cm), leaf length (36.20cm), leaf breadth (1.21cm), number of tillers per plant(26), number of productive tillers per plant (20), number of seeds per panicle (155), seed L / B ratio(2.52), seed yield per plant (33.00g), dry matter production (68.50g) and 1000 seed weight (24.50g) whereas the lower values for the above traits were registered in T_0 (control).

The minimum days to first flowering (70) and days to 50% flowering (73), were recorded in seed primed with $CaCl_2$ @ 1% followed by pelleted with *azospirillum* 600g/ha seeds which was 5.71% and 6.84% (Table 1) respectively earlier over control. Earliness in flowering characteristics of 1% $CaCl_2$ primed followed by *azospirillium* inoculated plant might be due to the early seed germination by the role of calcium priming in the germination process which is evident from the present study and due to increased availability of the nutrients and plant growth promoting substance by *azospirillium* which accelerates the faster emergence of the seedling thereby early flowering (Pawar *et al.*, 2003).

The maximum plant height of 80.20 cm (Table 1) was recorded by T_2which may be due to the production of GA_3 and more availability of other nutrients by the microorganism. It was due to GA_3 effect on elongation of internodes as GA3 has known to enhance cell elongation. In case of the untreated seeds T_0 (control), the plant registered the reduced plant height. The reduction in plant height may be due to the reduced cell size, cell thickening, reduced rate of enzyme activity and poor availability of nutrients to the growing seedlings which favours delayed emergence and reduces vigour (Thirumalaiswamy and Sakharam-Rao, 2016; Karivaratharaju and Ramkrishna, 2015).

Among the treatments, T_2 (seed primed with $CaCl_2$ @ 1% followed by pelleted with azospirillum 600g/ha) registered the more value of panicle length, leaf length and leaf breadth which were 12.72%, 30.38% and 16.52% respectively (Table 1) over other treatments and control.The improvement in vegetative growth parameters (days to 50% flowering, plant height, panicle length, leaf length and leaf breadth) may be attributed to the escalating effect of primed and pelleted seed,which could have triggered the biosynthesis of nucleic acids, proteins and the consequential enhancement of cell division as well as the plant's enhanced metabolic activity resulting in the increased uptake of nutrients which are associated with improved crop growth (Sabir-Ahamed ,2003).This result is related to the action of the phytormones present in the biostimulant composition, which can stimulate stretching and cell division as reported by Taiz and Zeiger (2012).

In the present study, number of tillers per plant, number of productive tillers per plant, number of seeds per panicle, seed L / B ratio, seed yield per plant (g), dry matter production (g), and 1000 seed weight (g) which were 15.38%, 25%, 18.06%, 4.76%, 15.15%, 15.32% and 5.30% increase over the control (Table 1) was recorded by T_2. The beneficial effect of T_2 could be attributed to improved mobilization of nutrient and moisture supply from pre-sowing seeds, which could have resulted in enhanced fertilization, resulting in lower number of sterile spikelet's as reported by Patil *et al.* (2014) and Amin *et al.* (2016). This may also be due to better nutrient uptake and plant photosynthesis through improving bio-fertilizer activity, which results in better flowering and heading. Also, the positive effect of seed primed with $CaCl_2$ followed by pelleted with

azospirillum can be attributed to increased water and nutrient uptake due to development and expansion of roots and biological nitrogen fixation by bio-fertilizer (Mirzaei *et al*., 2010).

Improved single plant yield, dry matter production and seed yield by T_2 (seed primed with $CaCl_2$ @ 1% followed by pelleted with *azospirillum* 600g/ha)as compared to the control may be due to accelerated protein and nucleic acid synthesis, bound water content, improved photo assimilation and its translocation and partitioning from source to sink, enhanced germination and growth of seedling resulting in increased uptake of nutrients, reduced spikelet sterility with more filled seeds and positive impact of treated plants to unfavorable condition. Higher yield and yield attributes by $CaCl_2$ @ 1% seed primingthen pelleted with *azospirillum* 600g/ha can also be associated to significant improvement in plant height (cm), panicle length (cm), number of tillers per plant, number of productive tillers per plant, number of seeds per panicle, seed yield per plant (g), dry matter production (g) and 1000 seed weight (g) described above. Results are also in conformity with the reports of Sujatha and Ambika (2018) and Khalid *et al*. (2021) in rice

The lower values for growth and yield parameters registered by T_0(control) may be due to the reduced rate of enzyme activity and poor availability of nutrients to the growing seedlings which favours delayed emergence and reduced vigour that leads to poor plant growth. The lack of exogenous availability of bio-available substances, such as those found in T_2, could explain the control's stunted development and performance (Thirumalaiswamy and Sakharam-Rao, 2016; Karivaratharaju and Ramkrishna, 2015).

In the present study, Pre-sowing seed treatment (seed primed with $CaCl_2$ @ 1% followed by pelleted with azospirillum 600g/ha) seeds recorded higher values for the morpho-physiological characteristics of resultant seeds viz., germination percentage (90%), speed of germination (34.80), root length (25.20cm), shoot length (17.60cm), seedling length (42.80cm), seedling fresh weight (2.83g), seedling dry weight (0.27g), vigour index I (3834) and vigour index II (24) and lower values were recorded in control (Table 2).

The supremacy of the resultant seed from T_2may be related to the availability of more metabolites / stored reserves (better translocation from source to sink) which aids in resumption of embryonic growth during germination as well as the accumulation of more seed constituents (stored mRNA) and better DNA repair mechanism during germination and seedling emergence which in turns results in higher vigour. Similar results were reported by Amin *et al*. (2016), Pathirana and Yapa (2020) and Raja and Anandham (2020).

Thus, from the present investigation, the pre-sowing seed treatment (seed primed with $CaCl_2$ @ 1% followed by pelleted with azospirillum 600g/ha) showed a positive impact on vegetative growth, yield parameters and seed quality than the control.

Conclusion

In the present study, the treated seeds along with control were evaluated for the crop growth viz., days to first flowering, days to 50 per cent flowering, plant height, panicle length, leaf length, leaf breadth, number of tillers per plant and seed yield attributing parameters viz., number of productive tillers per plant, number of seeds per panicle, seed L/B ratio, seed yield per plant, dry matter production, 1000 seed weight and BCR under field condition.

Among the pre-sowing seed treatments, it was revealed that seed primed with $CaCl_2$ @ 1% then pelleted with *azospirillum* @ 600g/ha (T_2) recorded higher values for the growth parameters *viz*., days to first flowering (70 DAS), days to 50 per cent flowering (73 DAS), plant height (80.20cm), panicle length (23.50cm),leaf length (36.20cm), leaf breadth (1.21cm), number of tillers

per plant (26) and seed yield attributing parameters *viz*., number of productive tillers per plant (20), number of seeds per panicle (155), seed yield per plant (33.00g), dry matter production (68.50g), seed L/B ratio (2.52), 1000 seed weight (24.50g) and BCR (2.56) when compared to control (T0). The seeds harvested from the above treatment T_2 registered the better seed quality parameters *viz*., germination percentage (90%), speed of germination (34.80), root length (25.20cm), shoot length (17.60cm), seedling length (42.80cm), seedling fresh weight (2.83g), seedling dry weight (0.27g), vigour index I (3834) and vigour index II (24) and lower values were recorded in control.

From the study, it was concluded that rice seeds primed with $CaCl_2$ @ 1% then pelleted with *azospirillum* @ 600g/ha performed well for seed quality characters under lab condition as well as yield contributing characters under field condition when compared to other treatments.

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Table 1. Effect of pre-sowing seed treatment on crop growth and seed yield attributing Characters in rice

Treatment	Days to first flowering	Days to 50 per cent flowering	Plant height (cm)	Panicle length (cm)	Leaf length (cm)	Leaf breadth (cm)	Number of tillers per plant	Number of productive tillers per plant	Number of seeds per panicle	Seed L / B ratio	Seed yield per plant (g)	Dry matter production (g)	1000 seed weight (g)
T_0	74	78	70.00	20.51	25.20	1.01	22	15	127	2.40	28.00	58.00	23.20
T_1	71	74	75.80	20.58	32.00	1.15	24	18	148	2.46	31.50	64.00	24.00
T_2	70	73	80.20	23.50	36.20	1.21	26	20	155	2.52	33.00	68.50	24.50
T_3	71	74	77.80	22.54	34.00	1.18	24	18	150	2.46	32.00	67.40	24.20
T_4	72	76	73.80	23.00	30.30	1.08	22	17	135	2.45	29.50	62.00	23.80
T_5	73	76	75.50	21.00	31.00	1.14	23	18	147	2.43	30.00	63.00	23.60
T_6	72	75	76.40	23.00	34.50	1.18	24	18	152	2.47	32.00	67.60	23.90
T_7	72	75	75.10	22.00	33.10	1.17	23	17	149	2.46	31.00	67.00	23.80
T_8	73	77	72.30	20.80	29.00	1.05	22	16	133	2.42	29.00	61.00	23.50
T_9	71	74	78.40	23.20	35.10	1.19	25	19	153	2.50	32.50	68.20	24.40
Mean	71.90	75.20	75.10	22.01	31.98	1.136	23.60	17.59	144.90	2.455	30.85	64.67	23.89
S. ED	0.08	0.177	0.027	0.150	0.195	0.016	0.049	0.028	0.310	0.029	0.027	0.028	0.024
CD (0.05)	0.186	0.372	0.057	0.316	0.410	0.035	0.103	0.059	0.651	0.061	0.058	0.060	0.051

Table 2. Effect of pre-sowing seed treatment on seed quality characteristics of resultant seed in rice.

Treatment	**Germination %**	**Speed of germination**	**Root length (cm)**	Shoot length (cm)	Seedling length (cm)	Seedling fresh weight (g seedling^{-10})	Seedling dry weight (g seedling^{-10})	Vigour index I	Vigour index II
T_0	79 (62.73)	27.13	17.00	13.80	30.80	1.62	0.16	2433	12
T_1	86 (68.02)	31.80	22.50	14.60	37.10	2.62	0.24	3190	20
T_2	90 (71.57)	34.80	25.20	17.60	42.80	2.83	0.27	3834	24
T_3	88 (69.73)	33.50	24.50	15.00	39.50	2.70	0.25	3476	22
T_4	83 (65.65)	30.10	20.10	13.60	33.70	2.40	0.20	2797	16
T_5	85 (67.21)	31.20	22.40	14.00	36.40	2.50	0.22	3094	18
T_6	88 (69.73)	32.96	24.10	15.00	39.00	2.68	0.25	3432	22
T_7	86 (68.02)	24.80	24.00	15.20	39.20	2.62	0.24	3371	20
T_8	82 (64.89)	30.70	18.90	13.00	31.90	2.30	0.18	2615	14
T_9	89 (70.63)	34.20	25.00	16.20	41.20	2.76	0.26	3666	23
Mean	85.6	31.11	22.35	14.80	37.15	2.50	0.2270	3191.60	19.10
S. ED	0.438	0.164	0.370	0.059	0.073	0.042	0.042	14.40	0.3807
CD (0.05)	0.915	0.344	0.774	0.124	0.153	0.089	0.089	30.09	0.7957

EFFICACY OF BOTANICAL PLANT EXTRACTS AGAINST POD BORER COMPLEX IN BLACKGRAM

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Abstract

A field trial in Annamalai University Experimental Farm was conducted to study the effect of botanical pesticides over pod borers in blackgram. The Randomized Block design was used and the plot of size 4x3 m^2 were demarcated after sowing the blackgram seeds. Population levels of gram pod borer larvae, Plume moth larvae, spotted pod borer larvae, flower webber larvae and blue butterfly larvae were studied on 3 & 7 days after spraying. Results revealed the commercial product, Nimbicidine 1% solution to be more significant in reducing the larval population of blackgram pod borer complex. Neem 1% leaf extract was found effective over the pod borers next to commercially available Nimbicidine. The other two plant extracts viz., Nochi 1% leaf extract and Pungam 1% leaf extract was found to be least effective in reducing the pod borer incidence.

Keywords: *Botanicals, gram pod borer, Plume moth, spotted pod borer, flower webber, blue butterfly*

Introduction

During the past four decades, insect pest control has undergone spectacular changes with regard to concepts and methods, largely due to advances on understanding of insect biology and innovations in pest management technology. The study of biologically active substance in man’s environment has become increasingly important in recent years. This occurred concomitantly with our awareness of some undesirable side effects, as a result of modern synthetic pesticides.

Chemical pesticides have a dramatic initial impact and the end of pest problems seemed almost in sight but the dismal discovery that insects could develop resistance to these chemicals gave a shattering blow to the optimism of the nineteen forties. This situation generated a new wave of research.

The substance yielding from the plant world can make life hard for the insect that will kill, repel or interfere with its feeding. The floral treasure of India is the richest in the world, and finding of such plants and exploiting them in insect management are full of promise. Plants are known to produce a diverse range of secondary metabolites such as terpenoids, polyacetylenes, alkaloids, flavonoids, unusual aminoacids, sugars etc., These compounds possessing activities of insect growth regulators (IGR) and antifeedants. The large-scale utilization of botanical pesticides in IPM is limited by several factors-

- Almost every plant species shows some antifeedant / repellent activity. The identification of promising plant species suitable for utilization as botanical pesticides is a difficult task. Standardized bio-assay procedures need to be developed for efficient screening of plants.
- The results obtained with botanical pesticides are usually inconsistent. In many causes this problem is due to lack of quality control and could be overcome by developing suitable guidelines for registration of botanical pesticides.
- The mortality obtained is usually moderate and the required degree of control is not achieved in many cases.

- The trees like neem must be planted many years in advance. There is a long gestation period and only after that can these trees be used for obtaining pesticidal products.

A lot of work needs to be done before large-scale utilization of botanical pesticides in IPM becomes a reality. After identification of potentially useful species, intensive breeding and selection work will have to be undertaken for economic production of various high quality raw materials required for insecticide production. Simple formulation technology will have to be developed so that ready-to-use pesticides can be produced at local level. (Luckman and Metcalf, 1978). Quality control on botanical pesticides is a major problem. There is a wide variation in ecotypes, environmental factors, etc. Such variations affect the performance and shelf life of formulated products. There is an urgent need to develop and prescribe suitable standards for registration for these products.

Phytotoxic effects of neem have been reported in several crops including cabbage, onion, mustard, muskmelon, potato, tobacco, and tomato. Dosage response relationship need to be worked out carefully so that the farmers do not suffer any losses. The safety and selectivity of other botanical pesticides also should not be taken for granted. The new pharmacological and biochemical tools developed for evaluating the hazards of synthetic pesticides must be utilized for testing the promising botanical pesticides. These efforts will certainly enable us to identify selective, diverse, renewable, cheapand environmentally acceptable plant products from the repository of 'mother nature' for use in IPM programmes.

Pod borers in black gram:

Black gram is subjected to severe depredation to severe pest species, resulting in yield losses (Tiwari *et al*., 2016) which way range from moderate to very heavy. The major pod borers attacking black gram include

1-Gram pod borer, *Helicoverpaarmigera*, Noctuidae, Lepidoptera

2-Plume moth, *Exelastisatomosa* Pterophoridae, Lepidoptera

3-Spotted pod borer, *Marucatestulasis*, Pyraustidae, Lepidoptera

4-Flower webber, *Eublemmahemirrhoda*, Noctuidae, Lepidoptera

5-Blue butterflies, *Lampidesboeticus*,*Euchrysopscnejus*, Lycaenidae, Lepidoptera

6-Redgrampodfly, *Melangromyzaobtusa*, Agromyzidae, Diptera

7-Stem weevil, *Alcidodescollaris*, Curculiondae, and Coleoptera.

The caterpillar of gram pod borer *Helioverpaarmigera* first feed on foliage, later pods. The pod damage by *Helioverpa* is marked by a distinct circular hole made by the larvae when boring in the pod. Due to defoliation by gram pod borer harvest may be delayed by 2-3 weeks. Surveys in India indicate that pod damage across different states is around 5 to 15%. (Durairaj *et al*., 1998) All the other pod borers are not as significant as gram pod borer.

Methodology

A field trial in Annamalai University Experimental Farm were conducted to study the effect of botanical pesticides over pod borers in blackgram. The plot of size 4x3 m^2 were demarcated after sowing the blackgram seeds. The Randomized Block design of the experimental plot is as follows:

T_1R_1	T_3R_2	T_2R_3	T_4R_4
T_2R_1	T_1R_2	T_4R_3	T_3R_4
T_3R_1	T_4R_2	T_5R_3	T_2R_4
T_4R_1	T_5R_2	T_3R_3	T_1R_4
T_5R_1	T_2R_2	T_1R_3	T_5R_4

Treatments given include

T1- Nimbicidin 1% solution

T2- Neem 1% leaf extract

T3- Nochi 1% leaf extract

T4- Pungam 1% leaf extract and

T5- Control

The above five treatments were analyzed over the following pod borers of blackgram (Krishna *et al*., 2011)

1-Gram pod borer, *Helicoverpaarmigera*, Noctuidae, Lepidoptera

2-Plume moth, *Exelastisatomosa* Pterophoridae, Lepidoptera

3-Spotted pod borer, *Marucatestulasis*, Pyraustidae, Lepidoptera

4-Flower webber, *Eublemmahemirrhoda*, Noctuidae, Lepidoptera

5-Blue butterflies, *Lampidesboeticus*, *Euchrysopscnejus*, Lycaenidae, Lepidoptera

After taking the pre-treatment count, the first spray was done at 36 DAS, for this about 7.5 g of fresh leaves were soaked in 750 ml of water for 48 hours to spray a plot of 12 m^2 area. The supernatant solution is separated and this gives one percent leaf extract. Spraying was done with the help of knapsack sprayer. In the case of Nimbicidin, 7.5 ml of commercial solution is mixed with 750 ml of water and sprayed for an area of 12 m^2. In each plot, a plant population of 33 plants per metre square was maintained. In each replication plot, 5 potential plants were selected and tied with a twine for identification. Then the number of larvae were counted in the selected five plants before spraying, 3 days and 7 days after spraying, The second spray was done in 47 DAS and a count was taken three days after spraying.

Results and Discussion

Table 1. Population levels of gram pod borer larvae on blackgram*

Treatments	**Pre-count**	**3 days after 1st spray**	**7 days after 1st spray**	**3 days after 2nd spray**
T_1	5.00^a	3.00^{ab}	2.00^a	0.25^a
T_2	4.00^a	2.00^a	1.25^a	0.25^a
T_3	5.00^a	3.50^b	4.00^b	3.25^b
T_4	3.75^a	3.75^a	3.50^b	3.75^b
T_5	4.25^a	4.25^b	4.00^b	4.00^b
S.E	0.544	0.629	0.548	0.408
C.D	1.185	1.371	1.193	0.890

Values mean of four replications.

Means with different alphabet differ significantly at 5% level by DMRT.

* Average number of larva/5 plants.

Table 2. Population levels of Plume moth larvae on blackgram*

Treatments	Pre-count	3 days after 1st spray	7 days after 1st spray	3 days after 2nd spray
T_1	2.00^{a}	1.50^{a}	0.75^{a}	0.25^{a}
T_2	4.00^{a}	3.00^{ab}	1.25^{a}	1.00^{a}
T_3	3.25^{ab}	3.25^{b}	3.00^{b}	2.75^{b}
T_4	3.25^{ab}	3.25^{b}	2.50^{b}	2.50^{b}
T_5	4.25^{b}	4.25^{b}	4.25^{b}	4.00^{b}
S.E	0.698	0.692	0.443	0.528
C.D	1.521	1.508	1.964	1.151

Values mean of four replications.

Means with different alphabet differ significantly at 5% level by DMRT.

* Average number of larva/5 plants.

Table 3. Population levels of spotted pod borer larvae on blackgram*

Treatments	Pre-count	3 days after 1stspray	7 days after 1st spray	3 days after 2nd spray
T_1	3.25^{a}	2.00^{a}	1.25^{a}	0.50^{a}
T_2	3.25^{a}	2.25^{a}	1.50^{a}	0.75^{a}
T_3	3.25^{a}	2.75^{a}	2.25^{a}	2.00^{b}
T_4	4.25^{a}	4.00^{b}	3.50^{b}	3.25^{c}
T_5	3.75^{a}	3.75^{b}	4.25^{b}	4.00^{c}
S.E	0.447	0.452	0.470	0.423
C.D	0.974	0.985	1.024	0.922

Values mean of four replications.

Means with different alphabet differ significantly at 5% level by DMRT.

* Average number of larva/5 plants.

Table 4. Population levels of flower webber larvae on blackgram*

Treatments	Pre-count	3 days after 1st spray	7 days after 1st spray	3 days after 2nd spray
T_1	3.75^{a}	2.50^{a}	1.50^{a}	0.50^{a}
T_2	3.00^{a}	2.25^{a}	1.75^{a}	1.25^{ab}
T_3	2.75^{a}	2.75^{a}	2.25^{a}	2.00^{bc}
T_4	3.00^{a}	3.00^{a}	2.50^{a}	2.50^{c}
T_5	3.25^{a}	3.25^{a}	4.25^{b}	3.50^{d}
S.E	0.777	0.692	0.636	0.447
C.D	1.694	1.508	1.385	0.974

Values mean of four replications.

Means with different alphabet differ significantly at 5% level by DMRT.

* Average number of larva/5 plants.

Table 5. Population levels of blue butterfly larvae on blackgram*

Treatments	Pre-count	3 days after 1st spray	7 days after 1st spray	3 days after 2nd spray
T_1	2.50^{a}	1.50^{a}	1.00^{a}	0.25^{a}
T_2	3.00^{ab}	2.50^{ab}	1.75^{ab}	1.25^{a}
T_3	3.75^{ab}	3.75^{bc}	3.25^{cd}	2.75^{b}
T_4	8.00^{ab}	2.75^{ab}	2.75^{bc}	2.50^{b}
T_5	4.25^{b}	4.25^{c}	4.25^{d}	4.50^{c}
S.E	0.655	0.566	0.508	0.487
C.D	0.427	1.234	1.107	1.062

Values mean of four replications.

Means with different alphabet differ significantly at 5% level by DMRT.

* Average number of larva/5 plants.

Population levels of gram pod borer larvae on blackgram

In case of pre-count the incidence of gram pod borer was almost same in number. About first count *i.e* 3 days after spraying T_2-1% Neem leaf extract - had least number of larval populations followed by T_1-Nimbicidin. (Table 1). All the other treatments were on par with the control. After 7 days of first spraying T_1 and T_2 were found to be effective in reducing the larval population. Results were similar as obtained by Rabindra *et al*., 1998. The same trend was observed after the second spray. All the other treatments T_3-Nochi 1% leaf extract and T_4-Pungam 1% leaf extract were on par with the control. Thus, there was no significant effect on reduction of larval population regarding nochi and pungam leaf extracts.

Population levels of Plume moth larvae on blackgram

Here in the case of pre count, the plum moth incidence was almost same in number. After 3 days of first spray T_1-Nimbicidine found to be most effective in reducing the plant population followed by T_2-Neem 1% leaf extract. All the other were on par with the control (Table 2). After 7 days of first spray, the same trend was found to be followed. Then 3 days after second spray T_1 found to have least number of larvae followed by T_2. T_3 and T_4 are found to be very least effective and par with the control.

Population levels of spotted pod borer larvae on blackgram

With reference to pre-treatment count, the spotted pod borer larvae was same in number on all plots. After 3 days of first spray, $T_1$was found to be very effective followed by T_2 (Table 3). Here T_3 was found to be little significant over the reduction of larval population T_4 was on par with the control. The same trend was observed after 7 days of first spray as well as 3 days after second spray. In both the cases T_4 was on par with the control.

Population levels of flower webber larvae on blackgram

Here in the case of pre count, the flower webber larvae incidence was almost same on all plots. After 3 days of spraying, $T_{2\,was}$ found to be more effective followed byT_1-Nimbicidine. After 7 days of first spraying T_1 Nimbicidine was most significant followed by T_2- Neem 1% leaf extract

(Table 4). Here T_3 - Nochi 1% leaf extract and T_4 - Pungam 1% leaf extract were also found to have little effect over reduction of larval population. In case of 3 days and 2nd spray, same as on the previous case was observed about T_1 and T_2 butT_3 and T_4 are found to be on par with the control.

Population levels of blue butterfly larvae on blackgram

In the case of pre-count, the blue butterfly larvae were similar in all cases. After 3 days of first spray, T_1 Nimbicidine was found to be very effective in reducing the larval population followed by T_2 Neem 1% leaf extract. T_4 - Pungam 1% leaf extract was found to be little significant over the reduction of larval population. T_3 - Nochi 1% leaf extract was on par with the control (Table 5). Results were similar as obtained by Byrappa*et al*., 2012. After 7 days of first spray, the same trend was observed. After 3 days of second spray, T_1 Nimbicidine found to have little effect over reduction of larval population followed by T_2 -Neem 1% leaf extract T_3 and T_4 are found almost on par with the control.

Conclusion

The commercial product, Nimbicidine 1% solution was found to be more significant in reducing the larval population of blackgrampodborer complex. Neem 1% leaf extract was found effective over the podborers next to commercially available Nimbicidine. The other two plant extracts *viz.,*Nochi 1% leaf extract and Pungam 1% leaf extract was found to be least effective in reducing the podborer incidence. Thus, it could be concluded that any neem-based plant product / leaf extract can be recommended for eco-friendly control of blackgrampodborers.

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MEASURING THE IMPACT OF FOLIAGE ORNAMENTALS ON INDOOR AIR QUALITY IN DIGITAL PRINTING UNIT

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Abstract

Urban greening initiatives are a way of achieving ecological goals while reducing the undesirable effects of urban growth. Indoor air quality (IAQ) is essential to living environment and an issue for human health. People in hale 6 -10 lit/min of air (or) 15,000 lit/day. In modern time IAQ – poor ventilation reduce the RH, Increase the temperature and Indoor volatile organic compound more than 200 present in indoor. Indoor air has been found to be up to 100 times more polluted than outdoor air (Fisk, 2000). Printing industry is fast growing industry in the globe with multicoloured fascinated outputs. The materials used for printing are solvents such as ethanol, toluene, ethyl acetate, isopropanol, n-propanol, hexane, toluene-xylene-naphtha mixture, methyl ethyl ketone, isopropyl acetate, n-propyl acetate, glycols, and glycol ethers. At higher levels this may leads to modify the indoor air quality. Plants are found to remove toxic gases in the indoor atmosphere. It is well documented that plants in indoor space not only add aesthetic value, but contribute and promote the improvement of indoor air quality. Hence, this present study was taken up with an objective to study the impact of foliage ornamentals on Indoor air quality in Digital printing unit. Two indoor ornamental plants Codiaeum variegatum and Dieffenbachia on reducing the indoor air pollutants in an digital printing unit. Six plants of each genus separately were kept in an area of 10 x 10x 12 feet printing unit for three days. Preliminary data was observed without plants for and kept as control. The indoor air quality was monitored on hourly basis by smart air monitor and the data on temperature, humidity, CO_2, PM 2.5, carbon monoxide and ozone were recorded and analyzed. It is evident from the experiment that both the foliage ornamentals viz., Codiaeum variegatum and Dieffenbachia improved the indoorair quality placed in the digital printing unit.

Key words: *Indoor air quality, Plants, humidity, CO_2, PM 2.5, carbon monoxide and ozone*

Introduction

Developments in information technology have allowed people to connect and remain connected to the computer environment. However, this diffusion of information technology causes a great deal of stress, such as technostress, which is a modern disease of adaptation caused by an inability to cope with the new computer technologies in a healthy manner. They also stated that 9 indoor air pollutants [i.e., airborne bacterial count (ABC), carbon monoxide (CO), carbon dioxide (CO_2), formaldehyde (HCHO), nitrogen dioxide (NO_2), ozone (O_3), radon (Rn), respirable suspended particulates (RSP), and volatile organic compounds (VOCs)] and 3 thermal comfort parameters [i.e., Air velocity (V), Relative humidity (RH), and Temperature (T)) could affect people's health to a certain extent. According to studies on the measurement of indoor air quality (IAQ) that have been conducted by (Kim *et al*., 2013 and Pilidis *et al*., 2009, this variable is critical for health and quality of life. Therefore, the urban landscape designers are in a condition to search for a sustainable ecological and environmental approach. Potted plants can improve indoor air quality for building occupants, but of particular interest, (Carpenter, 1998) that just one plant

within the workspace can significantly enhance staff morale and simultaneously promote well-being and improve performance.

Printing industry is one of the commercial industry without which displays cannot be made. The indoor air quality present in the printing unit is vulnerable and causes harmful effects to humans (Aydemir and Ozsoy, 2020). The solvents widely used in printing industry are ethanol, toluene, ethyl acetate, isopropanol, n-propanol, hexane, toluene-xylene-naphtha mixture, methyl ethyl ketone, isopropyl acetate, n-propyl acetate, glycols, glycol ethers and water (Ozcelik, 2006; Rosch *et al*., 2014). These volatile compounds are highly toxic in exceeding levels. Cleaner air has also been found to have a causal relationship with better cardiovascular health and mental acuity. With this background information an experiment was carried out in a digital printing unit where the source of pollution seems to be more to study the influence of two foliage ornamental plants *viz., Codiaeum variegatum* and *Dieffenbachia* on minimizing indoor air pollution in digital printing unit.

Materials and Methods

This experiment was carried out to study the influence of two indoor ornamental plants *Codiaeum variegatum* and *Dieffenbachia* on reducing the indoor air pollutants in an digital printing unit. Six plants of each genus separately were kept in an area of 10 x 10 x 12 feet printing unit for three days. Preliminary data was observed without plants for and kept as control. The indoor air quality was monitored on hourly basis by smart air monitor and the data on temperature, humidity, CO2, PM 2.5, carbon monoxide and ozone were recorded and analyzed.

Results and Discussion

The control over environmental conditions, namely temperature, relative humidity, CO2 content, PM 2.5, ozone and Nitrogen dioxide worked well with the indoor plants in the test chamber.

Influence of Temperature and Humidity

The data on temperature does not show marked differences by the both the indoor plants tested and resulted non-significant. However, the data on relative humidity showed a gradual increase with the indoor plants. From the data, it was found that the humidity levels were found to be higher in the morning hours and reduced after 10 as the printing machines starts working during day hours. Among the two indoor plants, *Dieffenbachia* recorded 13.82 % increase over the initial humidity levels in the test chamber whereas the *Codiaeum variegatum* recorded with 1.61 % increase in humidity over initial data without plants. The increase in humidity levels may be since plants are known for removing pollutants from the air and contribute to enhancing interior air humidity through transpiration. Further, they can also reduce indoor temperatures and raise indoor humidity (Aydogan and Montoya, 2011); in addition, plant transpiration facilitates the convection of indoor air, which is an effective method of improving IAQ (Park *et al.*, 2008).

Influence of CO_2

CO_2 is one of the many common molecules found in the air. In this present study the concentration of co2 at initial levels were exceeded to 1640 ppm at 12.00 noon and in the second day of observation. It was evident form the data that, the CO_2 levels were reduced due to the indoor plants in the test chamber. Significant reduction in CO_2 concentration with 898.9 ppm over initial data (1219.2 ppm) was recorded under *Dieffenbachia*. The reduction in CO_2 levels accounted to be 26.22 percent over initial data. Similarly, the data on *Codiaeum variegatum* recorded a CO_2 concentraion of 941 ppm over initial data of 1219.2 ppm. A reduction of 25 % of CO_2 with the

initial data was observed under the test chamber with *Codiaeum variegatum.* The results of the present study indicated that plants can considerably decrease the CO_2 amount in the indoor air. Although plants are especially used for aesthetic and visual purposes, they affect the CO_2 amount in the environment (Cetin, 2015). The results of the present experiment are in accordance with the findings of Sevik *et al. (*2017).

Influence of PM 2.5

In this experiment, among the period of experiment, during the morning hours i.e. 9.30 to 10.30 am, the particulate was found to reach the peak (11 µg/m3 in both the days of initial observations). The results revealed that both the foliage plants reduced the PM content in the test room from 5.85 µg/m3 to 3.85 µg/m3 which accounts for about 34.1 % reduction over initial data under *Codiaeum variegatum*. Similarly, the data on *Dieffenbachia* recorded a maximum reduction from 5.85 µg/m3 to 2.95 µg/m3 which accounted around 49.6 % over initial data. According to Gawronska and Bakera (2015) PM is a mixture of solid and liquid phases and differs in size, origin, and chemical compositions. In this study, even though the PM is in safe level i.e. <50, both the plants reduced the PM level. The results obtained in this experiment are in conformity of the study made by Jiang (2007); Lohr and Mims (1996). Placement of the foliage plants indicated that they can contribute to reduce.

Influence of Ozone

Ozone (O3) consists of three oxygen atoms. In nature, it is created when the Ultra voiet (UV) light from the sun breaks down the oxygen molecule into two single oxygen atoms which quickly attaches itself to another oxygen molecule (O2) to become Ozone. Most countries adopt the OSHA standard for Industries and 50 ppb for indoor air quality requirements. The maximum ozone exposure limit of 50 ppb is also adopted by ASHRAE for IAQ requirements. From the experiment, the maximum of 8 ppb was recorded during the morning hours (9.30 am) and during the evening at 7.30 pm. However, the ozone level was reduced from 6.1 ppb (initial) to 4.4 ppb by *Codiaeum variegatum* and 3.6 ppb by *Dieffenbachia* with the initial data and with placement of plants respectively. The results from this study clearly showed that both the foliage plants are known for absorbing and detoxifying or degrading many harmful compounds such as NOx, CO, formaldehyde, benzene and others (Costa *et al*. 1995; Cornejo *et al*. 1999; Wolverton 2008), are also able to accumulate PM.

It is evident from the experiment that both the foliage ornamentals *viz.*, *Codiaeum variegatum* and *Dieffenbachia* improved the indoor air quality placed in the digital printing unit. This is possible through adsorption of gaseous contaminants and particulate (dust and bio aerosols) onto leaf surfaces; degradation of gaseous contaminants through various metabolic pathways; removal of CO2 and production of O2 through photosynthesis; increasing humidity levels through leaf transpiration and evaporation from rooting media and reducing airborne concentrations of dust and bio aerosols. Cosgrove (2005) stated that during the development of the leaf the plant cell walls undertake secondary cell wall formation, facilitated by expansion pro teins that allow for development of the cell wall by introduction of matrix polysaccharides such as cellulose, pectin, and hemi-cellulose. Moreover, it is also known that plants consume pollutants and transform them in "food" or other compounds. Plants clean the indoor air by absorbing pollutants into their leaves and transmitting the toxin to their roots, where they are turned into food for the plant (Afrin, 2009).

It is well documented that plants in indoor space not only add aesthetic value, but contribute and promote the improvement of indoor air quality. Likewise, ornamental plants can be effectively used as bio-indicators of air quality (Nugrahani *et al.*, 2012: Wuytack *et al.*, 2010). The most

sensitive part of the plant is leaf, and therefore, it is affected by air pollutants. Leaves play a major role in the absorption and accumulation of air pollutants to reduce the level of pollutants. The mechanism by which plants reduce or remove indoor air pollutants is done mainly through leaf stomata and after they have penetrated the leaf, in the intercellular spaces the gases are distributed and absorbed by water films.

From the experiment, it is concluded that, the two foliage ornamentals was found to influence greatly on improving the indoor air quality.

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Table.1. Performance of Indoor plants on the Indoor Air quality (IAQ) of digital printing unit

	Humidity (%)			**CO_2** (ppm)			**PM 2.5** (µg/m^3)			**Ozone (ppb)**			**NO_2(ppb)**		
Time	Control	P1	P2	Control	P1	P2	Control	P1	P2	Control	P1	P2	Control	P1	P2
6.30 am	63.4	66.2	66.9	803.5	777.5	729.5	3	2.5	2.5	4	4	4	0	0	0
7.30 am	65.3	68.2	69.4	794	714.5	699	3	3	2.5	4	4	4	1	0	0
8.30 am	65.4	66.7	68.9	784	717	705.5	2	2	1.5	4	4	4	0	0	0
9.30 am	58.2	65.0	67.0	1132	825	812	11	6	4.5	8	4	3	19	0	0
10.30 am	47.0	60.9	61.7	1266	878	848.5	10	6	5	5	4	3	0	0	0
11.30 am	54.7	62.1	62.9	1308	1014.5	924	3	3	2.5	5	3.5	3	0.5	0	0
12.30 pm	57.4	60.0	60.9	1640	1179	1143.5	8	4	2.5	6	4.5	3.5	0.5	0	0
1.30 pm	58.6	61.3	61.6	1145	1064	1002	6	3	2	5	4.5	3.5	0.5	0	0
2.30 pm	45.1	65.1	66.3	1722	990	952	10	6	4.5	7	4	3	1	0	0
3.30 pm	55.5	65.0	66.1	1708.5	988	938.5	8	4.5	3.5	7	5	4	0.5	0	0
4.30 pm	56.8	63.2	64.4	1419	991	962	5	3	2.5	7	5	4	1	0	0
5.30 pm	54.5	63.2	64.5	1185.5	1009	940.5	4.5	2.5	1.5	7.5	5	4	1	0	0
6.30 pm	56.0	61.7	62.5	1100	1076	1011	5	5	4	8	6	4	1	0	0
7.30 pm	63.8	66.8	67.6	1061	950	916.5	3	3	2.5	8	4	3.5	0.5	0	0
Mean	58	63.9	65.05	1219.2	941.0	898.9	5.85	3.82	2.96	6.10	4.4	3.6	1.89	0	0

Table.2. Comparitive assessment of Indoor air quality with and without pants

Air Quality	**Control (Without plants)**	**With Plants (Mean)**			
		PI	**% Difference**	**P2**	**% Difference**
Humidity (%)	57.25	63.9	11.61	65.05	13.82
Co2 (ppm)	1219.2	941	25	898.9	26.3
PM 2.5 (µg/m^3)	5.85	3.85	34.4	2.95	49.57
OZONE (ppb	6.1	4.4	27.8	3.6	41
No2 (ppb)	1.9	0	100	0	100

Fig.1 Impact of Indoor plants on humidity levels

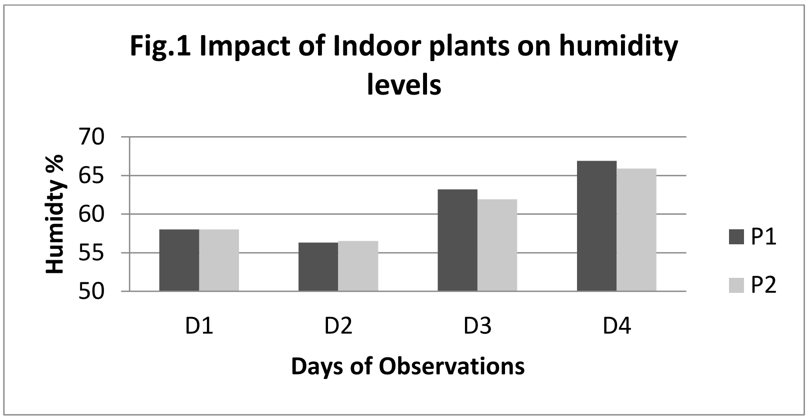


Fig 2. Impact of Indoor plants on CO_2 levels

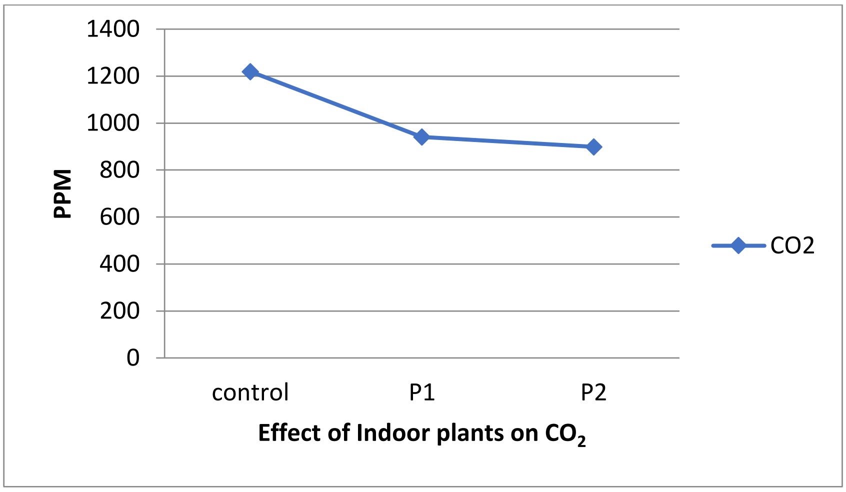


Fig 3. Impact of Indoor plants on PM levels

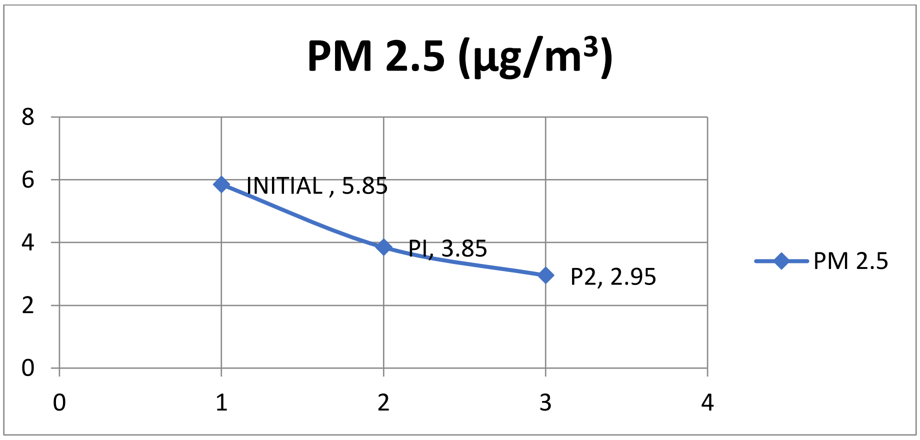


Fig 4. Impact of Indoor plants on Ozone levels

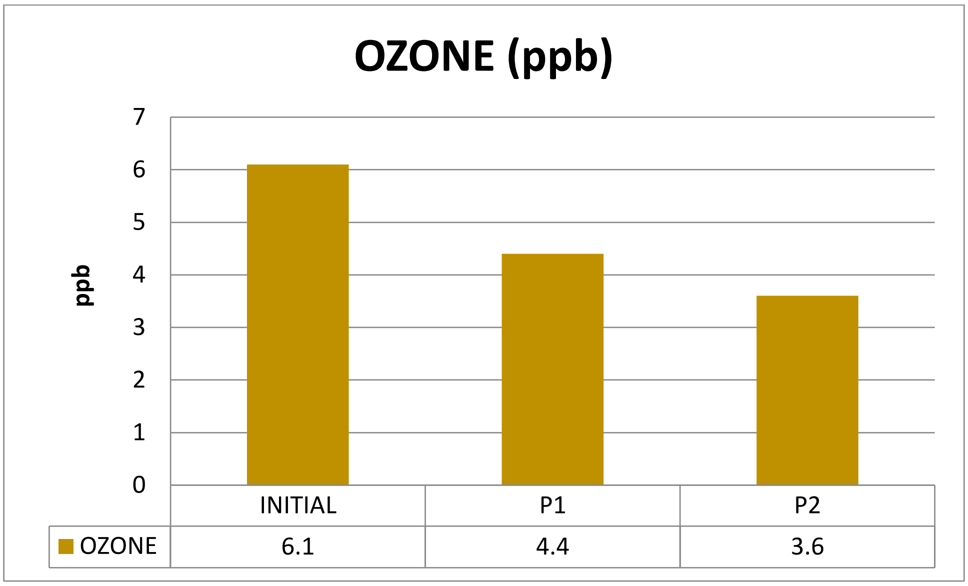
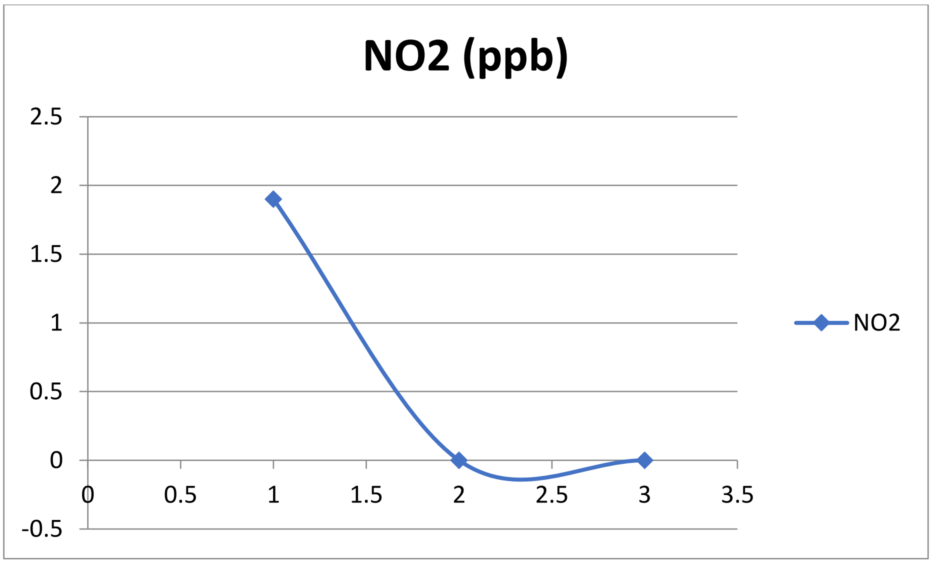


Fig 5. Impact of Indoor plants on NO_2 levels



SEXUAL DIMORPHISM IN AMARANTHUS LEAF WEBBER *Spoladea recurvalis* FABRICIUS (CRAMBIDAE: LEPIDOPTERA)

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Abstract

For effective identification or management of any pest, a complete and better understanding of its biology is inevitable. In this study visual morphology of adult Spoladea recurvalis were investigated. By testing 10 number of moths in each sex female and male under bright light revealing that the colour pattern of abdomen exhibiting white ring on each segment varies in number for female and male as 5 and 6 on the dorsal side of moth. While the ventral side of the abdomen shows differences in marking of the abdominal segments along with colour variations of the gonopore as orange to light brown in female and brown to black in male respectively. In addition, the male possess tuft of hair at the posterior end of the abdomen.

Key: *Spoladea recurvalis, Sexual dimorphism, adult morphology*

Introduction

The Amaranthus leaf webber or beet webworm *Spoladea recurvalis* Fabricius, belongs to the subfamily Spilomelinae, family Crambidae of order Lepidoptera, is a destructive vegetable crop pest both in tropic and subtropics with Amaranthus as the main host (Chang and Ramaswamy, 2018). Adult moths are nectarivores and capable of long distance flights (Shirai, 2006). Identification of sex is highly important factor for understanding the biology and management of pest (Lin *et al*., 2020). Most animal species has two distinct sexes and are exhibited as morphological, physiological, and behavioural levels to distinguish female and male (Benitez *et al*., 2011).

In Lepidoptera primary forces driving the evolution of sexual dimorphism are considered as sexual selection and mating system. Sexual dimorphism is a source of variation in morphology (wing shape and colour pattern) and behaviour (chemical and visual signaling) etc within species (Allen *et al*., 2011). Identifying Female and male is necessary for development of fast and convenient methods of gender related studies (Lin *et al*., 2020) and development of naval pest management strategies (Chang and Ramaswamy, 2018).

Hence, the present study focus on exploring the visual morphological sexual dimorphism (colour pattern) of *S. recurvalis*.

Materials and Methods

The test insect (adult moth) *S. recurvalis* (Crambidae: Lepidoptera), used for the study we are both lab cultured and field collected. Ten months of lab cultured and ten months of field collected in each sex were observed for the morphological (colour pattern) characters. The insect specimens were confirmed as *S. recurvalis* with the help of diagnostic description of the species provided in the website of India Biodiversity Portal.

(https://indiabiodiversity.org/species/show/268475).

As the *S. recurvalis* moths are small and fragile in nature, handling and observing were done under bright white light (Table lamp). The insects used in the study were freeze killed to avoid discolouration or damage of scales. Then the insect were pinned using entomological pins and

mounted on a foam, the wings were spread, to get a clear view of the abdomen. Five specimens pinned dorsally and five specimens ventrally in each sex.

Female Morphology - Abdomen of the specimen was observed and the white rings present at each abdominal segment were of five in numbers on the dorsal side. Whereas, the ventral side of the abdomen has inverted triangular marking at the middle or centre of each segment in black colour along with marginal parallel line marking. And the ventral posterior end of the abdomen where the surroundings of gonopore opening has orange to light brown colour and the abdomen was shorter with the posterior tip wider than the males. The sex of the specimens was verified by giving slight press at the posterior end of the abdomen using a needle which lead to the reproductive organs squeezed out of the abdomen.

Male Morphology - Abdomen of the specimen was observed and in males the white rings present at each abdominal segment were of six in numbers on the dorsal side. And the ventral side of the abdomen has short, not prominent, and pale central marking in black colour along with parallel line marking in black or dark brown on the lateral side. While the terminal segment has dark brown to light brown colour marking in addition with the tuft of hair. Abdomen was long and posterior tip of abdomen was narrow than the females. The sex of the specimens were verified by giving slight press at the posterior end of the abdomen using a needle which revealed reproductive organs.

Result and Discussion

Result of this study showed that the colour pattern on dorsal abdomen white ring marking and ventral black central marking in each segment along with the ventral posterior abdominal segment showing morphological traits to differentiate the female and male moths of *S. recurvalis*.

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IMPACTS OF BIOMASS BURNING ON ECOSYSTEM SERVICES

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Abstract

Burning biomass poses a severe concern and is currently a hot topic. In India, about 85–90% of biomass is burned in the field. Burning agricultural crop residue also contributes to the release of various pollutants that are harmful to human health. It also has a negative effect on the many ecosystem services, including those that are regulating, providing, sustaining, and cultural. It impacts pollinators, reduces soil fertility, changes soil structure, and influences how naturally pests and diseases are controlled. It lessens nematode, microbe, earthworm, insect, and pathogen biodiversity. Burning biomass removes nutrients, which has a significant impact on the ecology. Biomass burning removed around 2400, 35, 3.2, 21 and 2.7 kg of carbon, nitrogen, phosphorous, potassium, and sulphur from the soil. The cost to add those nutrients back to the soil using the replacement cost technique is Rs. 30834. The economic benefits of biomass include its usage as a source of energy, biofuel, compost, gasification, and bio-methanation. The effects of burning biomass and the uses of biomass must be understood by all parties involved.

Introduction

India is a highly populated agrarian country and although approximately 16.5% of India's GDP is devoted to agriculture, the industry nevertheless employs the majority of workers (around 42.3% in 2019)(Gulati and Juneja 2022). In 2022, the output of food grains reached a record high of 314.51 million tonnes (Mt) (Jha *et al*. 2022). The agricultural leftovers left behind after grain harvest are referred to as biomass. It is anticipated that the crop leftovers (biomass) from the food grains comprise roughly 500-550 Mt of biomass(Devi *et al*. 2017). These biomass crop wastes are utilised for mulching, livestock feed, manuring etc. But mostly they were burnt on the field itself for the preparation of field for following season harvest. The time was extremely less forfarmers to manage them efficiently and it needs some money or work to go for manure preparation or others.

In the Indo-Gangetic plains, the crop remnants of rice, wheat, maize, cotton, sugarcane, millets, and mustard were primarily burned in fields (IARI 2012). It is quite frequent in North West India notably in National Capital region (NCR) *i.e.*, Delhi, Haryana, Rajasthan, and Uttar Pradesh. Meanwhile, feed costs are climbing up significantly. The burning of biomass was centred in Punjab. From October 1 to November 10, the crop was largely burned.Burning agricultural crop residues can release pollutants such as CO_2, N_2O, CH_4, CO, NH_3, NO_x, SO_2, NMHC, VOCs, and SVOCs (Zhang *et al*. 2011, Jain *et al*. 2014). Burning crop leftovers also depletes resources and nutrients (Jain *et al*., 2014). Crop residues lose all of the carbon, 89–90% of the nitrogen, 25% of the phosphorus, 20% of the potassium, and 50% of the sulphur, which contributes to air pollution

(Raison 1979, Ponnamperuma 1984, Lefroy et al. 1994). According to studies by Jain et al., (2014), nutritional loss is 0.394% N, 0.014% P_2O_5, and 0.295% K_2O Mt/year, respectively.

Burning biomass alters the composition of the atmosphere, which may affect the radiation budget and contribute to climate change (Koppmann *et al*. 2005, Streets *et al*. 2006). Increased ozone, carbon monoxide, and aerosol levels as a result of biomass burning are a severe problem as well (Khodmanee and Amnuaylojaroen 2021). Regional, global, and radiative forcing are all impacted by aerosols (Jain *et al*. 2014). A false widespread belief is that biomass burning exclusively occurs when crop wastes are burned in agricultural areas. However, it also occurs as a result of deforestation, shifting agriculture, savannah fires, and the burning of fuel wood (Zhang *et al*. 2011).Forest burning accounts for the majority of biomass burning on a worldwide scale, with 2020 Tg (or about 25% of total burning) coming in second (Crutzen and Andreae 1990, Andreae and Merlet 2001, Chang and Song 2010).

Agricultural residue generation in India and burning of biomass

According to research by Jain *et al*., (2014), cereals provide 361.85 million tonnes of biomass, oilseeds 28.72 million tonnes, fibre crops 122.37 million tonnes, and sugarcane 107.50 million tonnes. Uttar Pradesh, Punjab, and Maharashtra are the top three states for residue burning, contributing around 60, 51, and 46 million tonnes, respectively. Jain *et al*., (2014) also calculated the amount of leftovers burned according to the crops. Cereals make up roughly 58% of the total, followed by sugarcane, oilseeds, and fibres at 17%, 5%, and 20%, respectively. Rice makes up over 53% of the grains, followed by wheat, millets, and maize at 33%, 7%, and 7%, respectively.

According to Mandal *et al*., (2004) findings, 350 Mt of crop residues were thought to have been produced. India has a gross crop residue potential of 696.38 million tonnes per year. Crop leftovers from cereal crops total roughly 364.27 million tonnes each year (Venkatramanan *et al*. 2021).The burned agricultural residues were calculated by Jain *et al*. and the IPCC using coefficients (2014). According to the IPCC coefficients, 131 million tonnes of biomass were burned in the year 2008–2009, whereas Jain and colleagues estimated 98 million tonnes of biomass were burned in the same year.

Ecosystem services

The benefits that humans derive from ecosystems are known as ecosystem services. These consist of provisioning services like food and water, regulating services like preventing floods and diseases, cultural services like spiritual, recreational, and cultural advantages, and supporting services like nutrient cycling that preserve the circumstances for life on Earth (Dinesh 2022).They are divided into four categories. They are provisioning, regulating, supporting and cultural services. Sometimes, the impact of climate change and anthropogenic interventions increases ecosystem disservices, which are often known as negative impacts(Dinesh *et al*. 2022).

Impacts of biomass burning on provisioning services

Products derived from ecosystems, such as genetic resources, food and fibre, and fresh water, are examples of provisioning services. Biomass burning indirectly impacts the food production by soil nutrients loss and destruction of soil organic carbon and biota. Biomass burning negatively impacts the production of food, fibre, fuel and fodder. Loss of provisioning services refers to how residue burning reduces agricultural profitability, either by raising production costs or lowering yields. Other negative effects besides yield reductions include lost job possibilities, a lack of raw materials for industry, a lack of feed, and higher input costs for farmers like irrigation and fertiliser(Kumar *et al*. 2019).

Impacts of biomass burning on supporting services

Ecosystem services that must be present in order for all other ecosystem services to be produced is known as supporting services. Examples include the creation of biomass, the creation of atmospheric oxygen, the formation and retention of soil, the cycling of nutrients and water, and the supply of habitat. Biomass burning destructs lot of supporting services provided by the natural and agro ecosystems.

1Impacts on soil

Burning has the following effects on soil, carbon dioxide emissions from soil organic matter, it also makes the soil's nitrogen balance fluctuates drastically, it also causes loss of different soil nutrients. According to Kumar *et al*., (2015), in the 0–15 cm layer, nitrogen is fully lost into the atmosphere due to crop residues burning. According to Gupta *et al*., (2004), a temperature increase of 33.8-42.2°C results in a loss of 27-73% nitrogen. According to some other research, every 10t of crop output removes 750kg of NPK from the soil. According to PAU, 0.824 mt of NPK nutrients were lost from the soil. Nematodes, microorganisms (bacteria, fungus, and actinomycetes), beneficial insects, weeds, snakes and reptiles, snails and mesofauna, are all lost due to biomass burning.

Nutrient losses as a result of burning biomass

Crop residue burning results in loss of nutrients as well as pollution. As a result of burning biomass, various amounts of nutrients were lost. The table below highlights the important nutrients that have been lost.The quantity of various nutrients lost as a result of the on-farm burning of rice straw, wheat straw, and sugarcane waste were also assessed in the study by (Jain *et al*. 2014). Burning sugarcane waste caused the most nutritional loss, followed by burning rice bran and wheat straw. Each year, the burning of sugar cane waste resulted in the loss of 0.84 Mt, 0.45 Mt, and 0.14 Mt of nutrients, of which 0.39 Mt were nitrogen, 0.014 Mt potassium, and 0.30 Mt were phosphorus.

Table. 1 Nutrient losses reported in various literatures

Nutrients	Lefroy *et al*., (1994)	Mandal *et al*., (2004)	Gadde *et al*., (2009)	Swamy *et al*., (2021)
C	-	-	-	2400 kg
N	80-90%	80%	25%	35 kg
P	25%	25%	25%	3.2 kg
K	20%	21%	75%	21 kg
S	50%	4-60%	50%	2.7 kg

Aerial pollution results from the loss of all of the carbon (C), 80–90% of the nitrogen (N), 25% of the phosphorus (P), the potassium (K), and the sulphur (S) that are contained in agricultural residues (Raison 1979, Ponnamperuma 1984, Lefroy et al. 1994). The quantity of various nutrients lost as a result of the on-farm burning of rice straw, wheat straw, and sugarcane waste was also assessed in the study mentioned above. Burning sugarcane waste caused the most nutritional loss, followed by burning rice bran and wheat straw. Each year, the burning of sugar cane waste resulted in the loss of 0.84 Mt, 0.45 Mt, and 0.14 Mt of nutrients, of which 0.39 Mt were nitrogen, 0.014 Mt potassium, and 0.30 Mt were phosphorus. The nutrient losses reported in various literatures were tabulated in the **Table.1**. The major states of Punjab, Uttar Pradesh, Haryana, and Maharashtra are where the majority of crop wastes were burned on farms. The three main crops whose leftovers are dealt with on farms are rice, wheat, and sugarcane. Large-scale agricultural waste burning from

the rice-wheat system in Punjab, Haryana, and western Uttar Pradesh raises major issues with pollution, health risks, and nutritional loss in addition to GHG emissions.

Impact of biomass burning on microbes

As a result of residue burning, the amount of microbial biomass is significantly decreased, but it gradually rebuilds or grows each year. According to research by Pietikäinen & Fritze, (1993), it takes about 36 years for the amount of microbial biomass to return to its pre-burning levels. According to research by Liu *et al*., (2007), the Microbial Biomass Number grew by 14.2% within 5 years and by 29.8% within 10 years. Unburned sites also had MBC and MBN that were 1.5 times greater than burnt sites. Kumar *et al*., (2015)reported that a 50% reduction in microbial population. Gupta *et al*., (2004) estimated that the top 2.5 cm of soil lost bacterial populations. Microbial activity and quantity affect soil productivity and nutrient cycling, they are essential for preserving soil fertility(Jenkinson and Ladd 1981). The majority of microbes were capable of detoxifying, accumulating, and effluxing metal ions, played a significant part in ecosystem(Sinduja *et al*. 2022a, 2022b). Additionally, they developed effective molecular mechanisms and ran particular metabolic pathways (Sinduja *et al*. 2022c).The numerous fires that frequently occur in this temperate wet region have a detrimental effect on the density and variety of soil microorganisms as well as soil structure. Burning significantly reduces the microbial biomass of these soils, whose recovery might take up to 13 years.

Impacts of biomass burning on earthworms:

Pheretimaalexandri, one of the largest and most prevalent species of earthworms at Medziphema, Nagaland, North Eastern India, is impacted by biomass burning. Few studies, including those by Reddy (1983) and Satchell (1983)reported the decrease in earthworm populations following fire episodes. In burnt castings, fire increased the amount of P_2O_5 and K_2O that was readily accessible while decreasing the pH and percentage of organic carbon. There is no research on how fire affects worms. Studies on the impact of fire on North Eastern Indian soils show declines in organic carbon content and increases in P_2O_5 and K_2O availability (Arunachalam and Arunachalam 2000). Alternatively, crop residues left in the soil as mulching material can positively impact the earthworm population and increases in the soil (Sharma *et al*. 2017).

Impacts of biomass burning on regulating services

The benefits derived by managing environmental processes, such as, for instance, the control of climate, water, and some human diseases, are known as regulating services.

Effects of burning biomass on honey bees

On three study blocks in the United States' Green River Game Management Area, pollinating insects were sampled. A total of 7921 floral guests from 21 families and four orders. The most numerous and diversified order, comprising 56.8% of all floral visitors, was the hymenoptera. Diptera include two families and 13 species, making up 23.6% of all floral visits. Unexpected outcomes in subsequent years Halictidae growing annually. In the burnt site and unburned areas listed below, both the orders of Hymenoptera and Diptera were significantly decreased (Campbell and Hanula 2007).

Impact of biomass burning on soil organic carbon

Burning biomass has an adverse effect on soil organic carbon, which has entirely decreased as a result. The effects of biomass burning were discovered by Parker et al., (2010)from the experiments at depths of 0-5 cm and 5–10 cm.After burning, the proportion of soil organic carbon decreased in both depths, although the fall in the 0-5 cm depth was 15% more than i 5-10 cm level,

and Scott et al. (1999)reported a similar finding in their research.Since there was a lot of organic matter and enough oxygen at the 0–5 cm depth, strong combustion and eventual oxidation of organic C into the atmosphere resulted from the intensive combustion in this zone. Additionally, soil moisture, organic matter, variations in texture, structure, and water holding capacity largely prevented the vertical transfer of surplus heat into the soil, reducing the impact of the heat on the top 5-10 cm of the soil. The findings suggested that the effects of heat on soil organic carbon are realistically substantial and should be opposed, especially by farmers who believe that burning biomass is the most effective approach to lower production costs. This is particularly feasible when farmers have the financial means to invest in mechanical tillage and agricultural techniques.

Emissions from biomass burning

Burning agricultural crop residue also contributes to the release of particulate matter, smoke, greenhouse gases (CO_2, N_2O, CH_4), air pollutants (CO, NH_3, NO_x, SO_2, NMHC), volatile organic compounds (VOCs), and greenhouse gases (CO_2, N_2O, CH_4) that are harmful to human health. The emissions from biomass burning showed in various literatureswere tabulated in the **Table. 2.**

Table. 2 Emissions showed in various literatures (Gg/year)

Pollutants	Venkataraman *et al.*, (2006)	Gupta *et al.*, (2004)	Gupta & Sahai, (2005)	Badarinath *et al.*, (2006)	Badarinath *et al.*, (2006)
BC	102-409	-	-	-	-
OC	399-1529	-	-	-	-
OM	663-2303	-	-	-	-
CO_2	224-638	-	-	-	-
CO	13-81	2138	2305	113	261
SO_2	66-238	-	-	-	-
NO_x	393-1540	78	84	8.6	19.8
CH_4	420-1486	102	110	1.33	3
NMVOC	2039-7406	-	-	-	-
NH_3	189-661	-	-	-	-
N_2O	-	2.2	2.3	-	-
PM_{10}	-	-	-	13	30
$PM_{2.5}$	851-3317	-	-	12	28.3

Impacts of biomass burning on cultural services

The non-material benefits that individuals derive from ecosystems via spiritual development, cognitive growth, introspection, leisure, and aesthetic experience are known as cultural services. These benefits include, for example, social networks, interpersonal relationships, and aesthetic ideals. The biomass burning indirectly impacts the cultural and aesthetic values of the human.

Effects of burning biomass on human health

Humans and other creatures are affected by the release of toxic compounds such as polychlorinated dibenzo-p-dioxins, polycyclic aromatic hydrocarbons (PAH), polychlorinated dibenzofurans (PCDF), and dioxins(Maceira *et al*. 2022). The negative effects including,animals dyingwhen their blood contains excessive levels of CO_2 and CO.$PM_{2.5}$ stimulates asthma, changes blood haemoglobin, lowers milk output, increases bronchial attack symptoms, and causes more

pain in pregnant women and children.Biomass burning also creates problems in cardiovascular and respiratory conditions(Chaitanya *et al*. 2022).

Methods for calculating the cost of burning biomass

For estimating the cost of loss in the ecosystem services through the biomass burning includes, replacement cost method, restoration cost approach, relocation pricing method and government payments procedure(UNEP 2014)**(Fig. 1).**

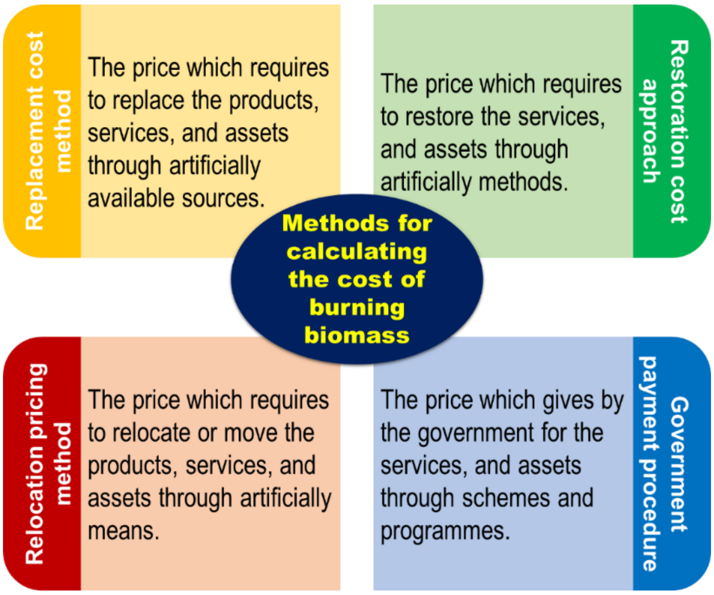

Fig. 1 Methods for calculating the cost of biomass burning and ecosystem disservices

Method for calculating replacement cost

According to the studies by Dinesh *et al*.(2021) and UNEP(2014), from the replacement cost method, Rs. 432 required to replace the nitrogen content in the soil, Rs. 171 for phosphorus content, Rs. 385 for potassium content, Rs. 25,000 for soil carbon content and Rs. 4846 for sulphur content. The calculationfor cost of biomass burning and ecosystem disservices were tabulated in the **Table. 3.**

Table. 3 Cost of biomass burning through replacement cost method

Nutrient	%	Nutrients required	Quantity required	Price
N	46	35	76.08	432.17
P	16	3.2	20	171.2
K	60	21	35	385
C	50	2500	5000	25000
S	13	35	269.23	4846.15
				Rs. 30834.53

Alternatives for biomass burning:

Alternatives to burning biomass include several profitable applications for crop waste, although farmers seldom adopt them. Crop wastes may be used to grow mushrooms, make compost, generate electricity, create biofuel, and feed them to cattle. In rural and village settings, it is also employed for thatching, mat production, and toy manufacturing (IARI 2012). Farmers in India typically rely on agricultural waste for feeding livestock. But because it is tasteless, difficult to digest, and contains a lot of silica (Gupta *et al*. 2004, Kumar *et al*. 2015). Sincesilica is hazardous to cow health, Punjab uses rice leftovers on cattle far less frequently than other provinces (Kumar *et al*. 2015). Farmers are reluctant to carry crop leftovers due to the high cost of transportation and

poor bulk density, according to Venkataraman *et al*., (2006), who also note that the use of crop residue as fodder was high in locations where the crop residue was greater.In IGP, conservation agriculture is becoming more popular as it utilises crop residues in the field itself as mulching (Dinesh *et al*. 2019, 2021). The compost heap may be successfully prepared to use crop leftovers. One of the most significant and vital energy sources in India is biomass. According to studies by Murali et al.(2008), India has the capacity to produce 511,041 tonnes of agricultural leftovers annually that may be used to generate biomass electricity.

Power plant in Fazilka–An alternative for North-Western India

Fazilka, Punjab, home to Asia's first biogas power plant. Running entirely in paddy straw. Harnessing 45% of the energy in biomass(Yadav *et al*. 2022). Northern India alone can generate 25,365 GW of power from 2.2 mt of biomass. Commercial-scale use of paddy straw for the generation of biomethane and bioethanol. Enhance biomass for use in home stoves Biomethane has tremendous potential and can take the place of gasoline as a transportation fuel. Manure produced by biogas plants can help with paddy cultivation. If the government begins to invest in this technology, 20% of the pollution issue in Delhi and the NCR will be solved in the next eight to nine years. Sampoorna Agri Venture Private Limited, a single firm, receives consulting services from IITians.Can replace up to 96.4% of Punjab's coal-based power facilities' entire output of energy(Yadav *et al*. 2022).

Conclusion

Crop burning diminishes the services offered by nature, which are difficult to substitute, and crop wastes have considerable economic worth as feed, fuel, livestock feed, and industrial raw materials. All stakeholders must be aware of the effects of burning biomass and its significant usage. It is crucial to emphasise that estimating the economic impact of losses to nature and ecosystems caused by burning straw is a challenge owing to the lack of knowledge on how these factors influence the soil, environment, and society or at least the long-term impacts. The incentives for not burning straw may encourage local innovators to come up with sustainable crop residue management strategies that maintain soil health while maintaining a clean and safe environment.

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SHELF LIFE STUDY OF *Azospirillum* BIOINOCULANT WITH LIGNITE AS CARRIER MATERIAL ALONG WITH DIFFERENT ORGANIC AMENDMENTS

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Abstract

In the present study experiments have been conducted to improve the shelf life of microbial inoculant of Azospirillum lipoferum by the addition of different organic amendments like sawdust, paddy straw powder, wood charcoal, farmyard manure and poultry manure with lignite as carrier material. The survivals of microbial inoculants were estimated at monthly intervals over a storage period of six months. Among the different amendments, sawdust at 2% level was found to record a maximum population of log 9.80cfu g^{-1} of carrier on the 6^{th} month of storage and a maximum moisture content of 36.23 percent. It was also observed that, the addition of organic amendment sawdust at 2% level was found to increase the survival of Azospirillum lipoferum up to six months of storage period at a required population.

Keywords: *Azospirillum lipoferum, Organic amendment, Viable Microbial, Population, Shelf life.*

Introduction

Biofertilizers have come to stay in Indian agriculture since last three decades in view of their cost effectiveness, contribution to crop productivity, soil sustainability and ecofriendly characters. Biofertilizers form an integral part of Integrated Plant Nutrient Supply system (IPNS) and organic farming which constitutes the present as well as future mandate of Indian agriculture. Biofertilizers manufactured in India presently are carrier based, in general, and suffer from short shelf life, poor quality, high contamination and low and unpredictable field performances. Death of the organisms in the inoculated seeds is one of the important factors contributing the failure of inoculation response in field condition. Research conducted on the inoculant production and formulation technologies is limited. A break through is needed in the inoculation technology to improve the shelf life and field efficacy of biofertilizer in India to make them commercially viable and acceptable to farmers. *Azospirillum* is one of the important biofertilizer, which is found to fix nitrogen in association with world's most staple food crops like rice, maize, sorghum, wheat and millets. In the present study experiments have been conducted to improve the shelf life of microbial inoculant of *Azospirillum lipoferum* by the addition of different organic amendments like Saw dust, Paddy straw powder, Wood charcoal, Farmyard manure and Poultry manure with lignite as carrier material.

Materials and Methods

Production of Carrier Based Inoculants

Preparation of broth

Nitrogen Free malic acid broth was prepared as per the composition and inoculated with *Azospirillum lipoferum* in 250 ml conical flask. It was allowed to multiply by incubating at 30 $\pm$ 2°C in a psychrotherm. (Model environ shaker 3597-1L BGM) incubator cum shaker at 100 rpm for 72 hours. The broth containing approximately 16.0 x 10^9/ml was used for mixing with carriers.

Preparation of carrier

The carrier materials collected were sundried, powdered, and sieved through 106 µ sieve.

Preparation of different organic amendments

The collection of different amendments *viz.,* Saw dust, Paddy straw powder, Wood charcoal, Farmyard manure, Poultry manure. These materials were shade dried powdered and sieved thorough 100µsieve and mixed with carriers.

Mixing of carrier and amendments

The neutralized carrier (lignite) was mixed with different organic amendments like sawdust (1& 2%), paddy straw powder (1 & 2%), wood charcoal (1 & 2%) farmyard manure (1 & 2%), poultry manure (1 & 2%) by manually. They were packed in 100g lots in opaque low density grade polypropylene bags of thickness 75 micron and sterilized as per the procedure followed by Somasegaran (1985).

Inoculation of broth culture in the sterile carriers with and without amendments

Broth culture having a cell load 10^9 cells ml^{-1} in late log phage was inoculated in carrier aseptically using sterile, plastic syringe fitted with hypodermic needle until 35 per cent moisture was obtained. The bags were thoroughly kneaded to ensure absorption of the liquid culture into the carrier.

Analysis of Carrier Based Inoculants

The inoculants packets prepared with amendments were stored at room temperature and analyzed for viable cell population, pH and moisture content at monthly interval up to six months of storage.

Estimation of *Azospirillum* population

The population of *Azospirillum* bacteria was enumerated by serial dilution and plating method. Serial dilution was prepared by transfer of 1g each of inoculum into 9ml sterile water blanks to get 10^{-1} dilution. Similarly, the dilution was made serially up to 10^{-9} from 10^{-1} dilution, one ml was pipetted out into sterile glass petriplates. The sterilized Nfb medium for *Azospirillum* was added. The plates were rotated clockwise and anti clockwise direction for uniform spread of the dilution mixture, the plates were incubated at 28 $\pm$ 3°C and the population were estimated.

Estimation of moisture content

The moisture content of the carrier based inoculants of *A. lipoferum* estimated by taking 10g of carrier material from each treatment.

The sample were oven dried at 70°C till constant weight was arrived and the moisture content of the inoculant carrier was expressed in percent.

Estimation of pH

Twenty gram of inoculant of *A. lipoferum* from each treatment was weighed and 40ml of distilled water was added. The sample was then vortexed for 5 minutes to get uniform mixing of carrier of carrier with the distilled water. The vortexed sample was allowed to settle for 30 min and then pH each treatment was determined using EC digital pH meter.

Results and Discussion

The survival of microbial inoculants, were estimated monthly intervals over storage period of six months and the results are presented in Table-1. The results revealed that all the amendments tested were able to increase the surviving population of *A. lipoferum*. Among the different amendments, saw dust at 2% level was found to record a maximum population of log 9.80 Cfu g^{-1} of carrier on the 6^{th} month of storage followed by paddy straw powder log 9.55 Cfu g^{-1}, poultry manure log 9.40 Cfu g^{-1}, farm yard manure log 9.03 Cfu g^{-1}, and wood charcoal log 8.40 Cfu g^{-1}.It

is also observed that, the population of *A.lipoferum* increased up to 3rd month in lignite with amendments, where as in lignite alone, the population increased only up to 1st month of storage.

The statistical analysis revealed that, the reduction in the population was not significant in lignite plus amendments, but in lignite alone showed statistically significant reduction in population of *A. lipoferum*. The increase in survival of *Azospirillum* by the addition of amendments like skimmed milk was reported by Fages, (1994). Many works have been carried out in this aspect. The increase in survival of microorganisms by the addition of different amendments like soya meal (Iswarana, 1972; Narendranath, 1995) and soybean powder (Kandasamy and Prasad, 1971) molasses (Iswaran & Jauhri, 1970) farmyard manure, composted straw powder, teak leaf powder (Tilak and Subba rao, 1978) mannitol (Kumar Rao *et al*., 1982) sucrose (Aarous and Ahmad, 1986) and polyvinyl pyrollidone (NIFTAL) were well documented.

The effect of different amendment on the moisture content of *A. lipoferum* inoculant was studied and the results of the study revealed that the moisture content of the *A. lipoferum* inoculant ranged from 35.30% to 37.40% at the initial stage and there after a gradual decrease in moisture content was noted in all the treatments.

At the end of the 6th month, the treatment lignite + sawdust (2%) recorded a maximum moisture content of 36.23 per cent, and the minimum moisture content of 30.20 per cent was recorded in lignite without amendments. It was also observed that all the treatment differed significantly with each other in then moisture content. The amendments contributed the moisture retention in the inoculants to a certain extent. There results agree with findings of Griffith and Roughly (1992).

The effect of different amendments on the pH of *A. lipoferum* inoculant was studied and it was observed that the pH content of *A. lipoferum* inoculant was at neutral condition initially and there was a gradual increase in the pH content in all the treatments and control. At the end of storage of 6th month period, the treatment lignite + poultry manure recorded the maximum pH of 7.62. In this study the maximum alteration in pH was noticed in poultry manure and farmyard manure. There results are in line with the findings of Santhanakrishnan and Thangaraju (2002).

Table - 1. Survival of *Azospirillum lipoferum* in sterilized lignite with different amendments

S. No	Treatments	Concentration (%)	Population of *A. lipoferum* inoculants log Cfu g^{-1}						
			Initial	1st month	2nd month	3rd month	4th month	5th month	6th month
1.	Saw dust	1	9.75	9.98	10.02	10.10	10.00	9.58	9.00
		2	9.74	10.20	10.40	10.60	10.25	10.00	9.80
2.	Paddy straw powder	1	9.73	9.80	9.99	10.02	9.91	9.43	9.00
		2	9.70	9.79	9.84	9.88	9.76	9.64	9.52
3.	Wood charcoal	1	9.96	9.98	10.00	10.01	9.60	8.70	8.30
		2	9.72	9.81	9.93	9.99	9.82	9.22	8.40
4.	Farmyard manure	1	9.74	9.97	9.98	9.99	9.21	9.16	8.90
		2	9.71	9.84	9.94	9.96	8.90	9.02	9.03

5.	Poultry manure	1	9.73	9.96	9.99	10.00	8.63	8.90	8.96
		2	9.76	9.98	9.99	10.01	9.23	9.30	9.42
6.	Control	-	9.73	10.00	9.95	9.60	9.00	8.60	8.00
	SEd		0.001	0.002	0.001	0.002	0.003	0.001	0.003
	CD (P=0.05)		0.003	0.004	0.002	0.003	0.006	0.002	0.006

Table-2. Effect of different amendments on the moisture content of *Azospirillum lipoferum* inoculants

Sl. No	**Treatments**	**Concentration (%)**	**Moisture content (%)**						
			Initial	**1st month**	**2nd month**	**3rd month**	**4th month**	**5th month**	**6th month**
1.	Saw dust	1	36.30	35.60	35.00	34.66	34.21	33.67	33.14
		2	37.16	38.82	37.90	37.76	37.26	36.59	36.23
2.	Paddy straw powder	1	36.30	35.70	34.68	34.40	33.49	33.20	32.41
		2	36.10	36.80	35.48	34.63	34.52	33.46	32.56
3.	Wood charcoal	1	35.08	34.40	33.62	33.24	32.47	32.08	30.75
		2	36.40	35.14	36.20	33.82	33.12	32.54	31.58
4.	Farmyard manure	1	36.40	34.75	34.20	33.64	33.00	32.53	31.58
		2	37.40	35.58	35.19	34.54	33.63	33.20	32.30
5.	Poultry manure	1	35.30	33.64	33.20	32.66	32.14	31.16	30.49
		2	35.40	34.75	34.24	33.54	33.30	32.00	32.22
6.	Control	-	35.30	25.30	35.30	34.10	32.30	31.00	30.20
	SEd		0.02	0.01	0.01	0.01	0.02	0.01	0.01
	CD (P=0.05)		0.04	0.03	0.02	0.02	0.03	0.02	0.02

Table - 3. Effect of different amendments on the pH of *Azospirillum lipoferum* inoculants

Sl. No	Treatments	Concentration (%)	pH of *A. lipoferum*						
			Initial	1st month	2nd month	3rd month	4th month	5th month	6th month
1.	Saw dust	1	7.00	7.27	7.29	7.30	7.30	7.32	7.33
		2	7.00	7.29	7.32	7.29	7.31	7.32	7.33
2.	Paddy straw powder	1	7.01	7.28	7.29	7.31	7.32	7.32	7.33
		2	7.00	7.30	7.31	7.31	7.31	7.32	7.32
3.	Wood charcoal	1	7.01	7.52	7.53	7.55	7.56	7.59	7.55
		2	7.00	7.53	7.57	7.58	7.57	7.55	7.57
4.	Farmyard manure	1	7.00	7.52	7.53	7.54	7.56	7.57	7.58
		2	7.01	7.60	7.61	7.63	7.64	7.63	7.62
5.	Poultry manure	1	7.00	7.63	7.62	7.62	7.60	7.58	7.58
		2	7.01	7.58	7.59	7.59	7.60	7.61	7.62
6.	Control	-	7.00	7.26	7.30	7.28	7.31	7.30	7.31

Based on the results of this study, the lignite can be used as carrier material to prepare the microbial inoculants. The addition of organic amendment such as sawdust at 2% level was found to increase the survival of microbial inoculants up to six months of storage period.

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IMPACT OF CLIMATE CHANGE ON SOME AGRICULTURALLY IMPORTANT INSECT PESTS

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Abstract

Climate change is one of the worldsnew emerging challenges. Climate change refers to statistical deviation in the mean state of the climate or its variation over loner period of timeIPCC, 2001). Concerns about the food security have been increased day by day for growing population. Several internal, external and man made factors responsible for climate change. This changing climate may lead to invite flood, drought, strome, and pest and weed invasion. Especially, increment of greenhouse gases in atmosphere, erratic and uneven distribution of rainfall, raised temperature are the major results of climate change. Among the different biological constraints in agriculture, pest is the major one next to weeds and accounting for 26%. Timely management of pest's incidence below the economic threshold level is the important agro technique for sustainable agriculture. However, this changing climate may have a chance to new pest invasion. In pest management, distribution of insects, enhanced diversity, increased survival ability, reduction in the effectiveness of existing management practices,evolution of new biotypes and increasing the risk of invasion by migratory insect pests are the result of climate change.Although efforts are made to mitigate the effects of climate change by developing simulation models, monitoring pest population and climate, and improving pest management tactics, in many developing countries, these simulation models and software models are still underused.Climate smart pest management strategies like pest risk forecasting, pest diagnosis and surveillance, farmer networking, climate information and projectionhas to be taken to mitigate the impact of climate change.

Keywords: *Food Security, Agriculture, Insect Pest, Climate Change*

Introduction

The introduction of the industrial revolution at the end of the eighteenth century resulted in increased usage of natural resources such as fossil fuel and wood for timber and fuel production, leading to large-scale deforestation. These deforested lands are then converted into agricultural lands, thus leading to the increased production of greenhouse gases like methane, carbon dioxide, chlorofluorocarbons, and nitrous oxide. These gases traps the long wave radiations emitted by the earth's surface and increase the earth's temperature and this effect is called global warming. This global warming led to warmer earth temperatures, uncertainty in rainfall and frequency in the occurrence of floods and droughts. These changes in climatic parameters over time are referred to as climate change. Population growth over time has gradually increased the demand for agricultural production. Instead of adding more land to agriculture, researchers have discovered that enhancing crop yield is the most sustainable crop production approach (Godfray *et al.*, 2010). To meet the needs of growing population, agricultural production must be doubled by 2050 (Tilman *et al.*,

2011). Today's technology advancements place a greater emphasis on food security. Storms, drought, flooding, increased temperatures, and increased greenhouse gases, especially carbon dioxide are the main threats to Food security (Andrews and Hodge (2010) and Tripathi *et al.,* 2016). According to IPCC2007 climate change report, the average earth's temperature has increased to over 0.6-degree centigrade over the last 100 years (1900-2000). The annual average temperature of the earth in 2021 is 0.85℃ andthe current atmospheric carbon dioxide level is 419ppm (NASA, 2022). If the emission of greenhouse gases continues to increase, the global temperature will rise up to 5.8 ℃ by the end of the 21st century (IPCC, 2007). Due to their small size, ectothermic lifestyle and several life history traits like survival, voltinism and growth rate, insects are very sensitive to abiotic fluctuations (Parmesan and Yohe, 2003). Insecttransmitted diseases are becoming more problematic due to climate change.

Agricultural production is being impacted by climate change in terms of both quality and quantity (Tripathi *et al.,* 2016). The effect of climate change will vary from location to region, crop to crop and species to species. Several models and protocols have been developed to mitigate the influence of climate change. However, all these are largely followed in developed countries. In developing countries, there is a large vacuum in this area-the assessment of direct and indirect consequences of global warming on various crops contributing to our food security must be done (Aggarwal, 2003). Planning research and development efforts for integrated pest management in the future requirestakingclimate change and global warming into account (Sharma, 2010). Keeping these points in view, this article is addressed to evaluate the impact of climate change on agriculturally important pests.

Impact of Climate Change on Insect Pest

Under changing climate atmospheric carbon di oxide, temperature and precipitations are change frequently and possess serious challenge for food security.

Elevated Temperature

Insects are poikilothermic (cold-blooded) organisms that maintain their body temperature approximately the same as the environment. Therefore, temperature is the single most important environmental factor influencing insect distribution, development, survival, behaviorand reproduction. Changes in geographical range, changes in population growth rates, overwintering, number of generations per annum, dispersal and migration, availability of host plant refugia, crop pests, synchronization, changes in host plant resistance, changes in biotypes, increased risk of invasive species, the introduction of the alternative host plant, Effects on the extinction of species, Reduced efficacy of crop protection technologies are few notable effects of temperature on insects pest (Pareek *et al.,* 2017 and Porter *et al*., 1991). Changes in temperature will mostly have an impact on insects to a certain extent and those effects are furnished in Table 1. Insects that live in soil survive better than those living on the surface as the soil provides better insulation to soiltemperature than the air temperature, which the surface insects suffer (Bale *et al.,* 2002).

Elevated Carbon Dioxide

Insects will be indirectly affected by elevated CO_2 levels in the air brought on by raising GHGs emissions because leaves will contain more amount of simple sugar and less nitrogen. As a result, additional sugar-loving insects are drawn to the plants, where they might harm them. Plant photosynthesis and photosynthate production are positively impacted by CO_2 availability (Osbrink *et al.*, 1987 Besford *et al*., 1990 and Groninger *et al*., 1996). Although photo-synthesis rates first rise with elevated CO_2 levels, they may eventually fall (Besford *et al*., 1990). The effect of increased levels of CO_2 varies from insect to insect. In Bemisiatabaci, the elevated CO_2 levels

increased the egg to adult development time and reduced the reproductive responses (De Paulo *et al*., 2020). Elevated CO_2 reduced amino acid levels in the phloem of cotton plants, but did not affect the level of amino acids in aphids (*Aphis gossypii*) tissue or honeydew produced by aphids. Aphids ingest more photosynthate to maintain theirdevelopment and growth on their host plant (Sun *et al.,* 2009). Higher consumption, lower digestion efficiency, slower growth and longer time to pupation (one day more than ambient) tissue or honeydew produced by aphids (*Aphis gossypii*) tissue or honeydew produced by aphids. Aphids ingest more photosynthate to maintain their development and growth on their host plant (Sun *et al.*, 2009). Higher consumption, lower digestion efficiency, slower growth, and longer time to pupation (one day more than ambient) of Spodoptera litura were the result of altered the quality of the peanut foliage due to increased CO_2 (Srinivasa *et al*., 2012). Report evadite more consumption by cotton bollworm (*Helicoverpa armigera*) on maize due to higher CO2 in the atmosphere. (Yin *et al*., 2010). Under condition of elevated CO_2, the damage caused by Japanese beetle, potato leafhopper, western corn rootworm and Mexican bean beetle on soya bean had increased to 57% (Kambrekar *et al*., 2015). The Pine sawfly, *Neodiprionlecontei*, demonstrated improved nitrogen uptake efficiency when raised on plant exposed to higher CO2 concentration (Williams *et al.,* 1994). Here are few instances of how elevated CO_2 effects insects.

Precipitation

In general, there are four ways that Precipitation can control insect population or crop damage caused by insect pest: as soil moisture when the insects are in the ground; as a mechanical factor that directly acts on them when exposed; through its effect on food plants; and by its effects on natural enemies of the pests (Beirne *et al.,* 1970). Since some insects are sensitive to precipitation and large rainfall can kill or remov them from crops (Deka *et al.,* 2011). Precipitation has a duel impact on insect pests. In the sub-Saharan desert area ofAfrica, changes in rainfall patterns have led to migratory patterns of the Desert Locust *(Schistocerca gregaria*) (Cheke *et al.*, 2007 and Hulme *et al.*, 2001). According to Studies on brown plant hopper, the population of BPH rises as precipitation increases 400 ppm and falls as precipitation increases over 500 ppm (Kambrekar *et al*., 2015). Higher November rainfall was associated with a more severe infestation of corn ear worm (*Helicoverpa armigera)* infestation, according to the variation in rainfall throughout the monsoon and November (Srivastava *et al.,* 2010). Wireworms (*Agrioteslineatus*) soil-dwelling insect that are influenced by summer rainfall and drought conditions to reproduce quickly in the upper soil. Staley *et al*., 2007). Heavy rain is a useful method for managing onion thrips, as it wash away the thrips attacking the onion (Reiners & Petzoldt, 2000). Rainfall and sprinkler irrigation on wheat and other crops have an adverse on the aphid population(Chander, 1998 and Daebelerand Hinz, 1977).

Table 1. The impact of elevated temperature on insect pest

S. No.	Name of insect	Effect oftemperature	References
1	Spruce beetle *(Dendroctonusrufipennis)* (Scolytidae, Coleoptera)	Increased temperatures have halved the time required to reproduce.	(Berg *et al.*, 2006)
2	Aphids *(Aphis gossypii)* (Aphididae, Hemiptera)	2°C increases in temperature can cause 1-5 additional lifecycles per season	(Yamamura *et al.*, 1998)
3	Brown plant hopper *(Nilparvatalugens)* (Delphacidae, Hemiptera)	Global warming is likely to increase BPH abundance in areas with temperatures below 30^0C	(Heong *et al.*, 1995)
4	Rice ear head bug *(Leptocorisa acuta)* (Alydidae, Hemiptera)	The rise in daily average temperature by 3^0C caused 1-3 days increase in generation time.	(Reji and Chander., 2008)
5	Rice green leaf hopper *(Nephotettixcincticeps)* (Cicadellidae, Hemiptera)	An increase in winter temperature has enhanced the abundance of this species.	(Yamamura *et al.*, 2006)
6	Gypsy moth *(Lymantria dispar)* (Erebidae, lepidoptera)	Higher temperature increases its performance by decreasing development time and increasing its survival time.	(Williams *et al.*, 2003)
7	Coffee brown beetle *(Hypothenemushampei)* (Curculionidae, *Coleoptera*)	Due to the temperature rise, their density has increased over time.	(Läderach *et al.*, 2010)

Conclusion

Climate change is the greatest challenge the human race is facing now. Climate change disrupted the balance between insect crop pests and their natural enemies, particularly in the tropics. It is impacting the biology, distribution and outbreak of potential pest in a vast range of crops across the globe. Upto 40% of world's food supply is already lost to pests. Therefore, it is high time to understand, prevent and as well mitigate the impacts of climate change, throughreducing GHGs emissions, controlling pollution of land, air, and water. It also includes preserving nature and

managing forests, vegetation, crops, and animals sustainably and following Climate smart pest management strategies like pest risk forecasting, pest diagnosis and surveillance, farmer networking, climate information and projection, policies and incentives, regulation of agro-inputs and agro-input suppliers, national and international funding mechanisms have to be taken to mitigate the impact of climate change.

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INFLUENCE OF DIFFERENT MICRONUTRIENTS ON YIELD PARAMETERS OF TURMERIC (*Curcuma longa*) cv. BSR 2

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Abstract

Turmeric (Curcuma longa L.) is an important spice cum medicinal plant belongs to the family zingiberaceae and native of tropical South East Asia. Turmeric inhibits the development of cataracts, breast cancer, colon cancer and lymphoma. However, except from its medicinal use, its fresh juice the aqueous extracts and the essential oil of the plant are credited with pesticidal properties against mosquito. An experiment was conducted in a farmer's field at Bharathipuram village, Pennagaram Taluk, Dharmapuri District, Tamil Nadu during May to January 2021 to study the influence of different micro nutrients on yield parameters of turmeric. Turmeric cv. BSR_2 was used for the experiment. The experiment was laid out in Randomized Block Design with nine treatments and three replications. The treatments comprised of soil application of boron (Borax), Manganese ($MnSO_4$), Iron ($FeSO_4$) and Zinc ($ZnSO_4$) each @ 25 kg ha^{-1}, foliar application of boron (Borax), Manganese ($MnSO_4$), Iron ($FeSO_4$) and Zinc ($ZnSO_4$) each @ 0.5% after 60 and 90 days after planting. In control no micro nutrients were applied. Inorganic fertilizers were applied at the rate of 80:80:120 kg $ha^{-1}$of N: P_2O_5: K_2O to all the treatments. Observations on yield parameters like number of mother rhizomes per plant, number of primary fingers per plant, number of secondary fingersper plant, yield per plant and yield per hectare were recorded. The results revealed that soil application of boron as borax @ 25 kg ha^{-1} recorded the highest yield parameters of turmeric cv BSR_2.

***Keywords**: Turmeric, Micro nutrients, BSR_2 and yield parameters*

Introduction

Turmeric (*Curcuma longa* L.), also known as 'Golden Spice', is one of the most important and ancient spices of India, ranking first in area, production, consumption and export in the world. West Bengal is one of the major turmeric producing states of India. Apart from its spice and medicinal value it is also used in the dye, food, and cosmetic industries. It is also used in the auspicious religious occasions. Turmeric inhibits the development of cataracts, breast cancer, colon cancer and lymphoma (Devi and Sangamithra, 2011). The active constituents present in turmeric is curcumin, which comprise 0.3-5.5 per cent (Leung, 1980). Curcuminoids in turmerichave anti-inflammatory, anti-mutagen, anticancer, antibacterial, antifungal, antiparasitic and detoxifying properties (Uechi *et al*., 2000).

Mineral nutrition is also considered as one of the important factors that influence the growth and yield of turmeric plant get some amount of nutrition from soil but they are inadequate to meet the increased demand of plants for higher production. Optimum dose of fertilizer is required by the crop to increase the productivity potential and there is enough information regarding the requirement of the nitrogen, phosphorus, and potassium by this crop. In addition to N, P, K, boron, manganese, zinc and iron are required by most of the crop plants particularly in rhizomatous crop

like turmeric for improving the yield characters. Very few information is available with respect to the effect of boron, manganese, zinc and iron on the growth and yield of turmeric. Keeping in this view, the present investigation was undertaken with the effect of different micro nutrients on yield parameters of turmeric cv. BSR_2.

Materials and Methods

An experiment was carried out in the farmers field, Bharathipuram village, Pennagaram Taluk, Dharmapuri District during May to January 2021. Turmeric cv. BSR_2 was used for the experiment. BSR_2 is a mutant from Erode local type released in 1994, medium statured, short duration crop, high yielding and resistant to scale insects. The experiment was laid out in Randomized Block Design with nine treatments and three replications. The treatments comprised of soil application of boron (Borax), Manganese ($MnSO_4$), Zinc ($ZnSO_4$) and Iron ($FeSO_4$) each @ 25 kg ha^{-1}, foliar application of boron (Borax), Manganese ($MnSO_4$), Zinc ($ZnSO_4$) and Iron ($FeSO_4$) each @ 0.5% after 60 and 90 days after planting. In control no micro nutrients were applied. Main field is ploughed four times. FYM @ 15t ha^{-1} was applied as basal to all the treatments. Inorganic fertilizers were applied at the rate of 80:80:120 kg $ha^{-1}$of N: P_2O_5: K_2O to all the treatments. Full dose of P_2O_5 and one third dose of nitrogen was applied as basal, remaining two third nitrogen and K_2O were applied in two equal splits at 45 and 90 days after planting. The rhizomes are planted at a spacing of 45x 10 cm. 30g weight rhizomes are dibbled at a depth of 4 cm. Observations were recorded on yield parameters such as number of mothers rhizomesper plant, number of primary fingersper plant, number of secondary fingersper plant, yield per plant and yield per hectare. The data was statistically analysed as per the method suggested by Gomez and Gomez (1984) and wherever the treatment differences were found significant critical differences were worked at 5% level of significance.

Results and Discussion

Growth attributes

Perusal of the data (Table 1) revealed increases in all the yield attributes of turmeric due to application of micronutrients over control.

Yield parameters like number of mother rhizomes (4.73) number of primary fingers per plant (14.28), number of secondary fingers per plant (7.21), yield per plant (335.55 g) and yield per hectare (29.43 t ha^{-1}) was observedwith the soil application of boron (as borax) @ 25 kg ha^{-1}. This was followed by the treatment which received the foliar application of zinc ($ZnSO_4$) @ 25 kg ha^{-1} which recorded number of mother rhizomes (4.56) number of primary fingers per plant (13.45), number of secondary fingers per plant (6.86), yield per plant (323.29 g) and yield per hectare (28.31 t ha^{-1}). The least yield parameters were recorded in the control where no micro nutrients were applied. The substantial increase in the yield attributes of turmeric could be ascribed to the direct involvement of micronutrients in improving the photosynthetic activity, protein synthesis and reproduction (Hnamte et al, 2018). Boron is essential for cell division and development transports carbohydrate in the plant which in turn improve the growth andyield parameters of turmeric (Halder et al., 2007). Thiripurasundari et al., 2014 reported that application of boron as borax improves the DNA synthesis which in turn improved the yield parameters of turmeric.

Conclusion

Based on the present investigation entitled, Influence of different micronutrients on yield parameters of turmeric cv. BSR_2, it can be concluded that the soil application of boron (as borax) @ 25 kg ha^{-1} resulted in improving the yield parameters of turmeric.

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Table1. Influence of different micronutrients on yield parameters of turmeric cv. BSR_2

Treatment Details	**Number of mother rhizomes per plant**	**Number of primary fingers per plant**	**Number of secondary fingers per plant**	**Yield per plant (g)**	**Yield per hectare (tonnes)**
T_1- Borax @ 25kg ha^{-1} (SA)	4.73	14.28	7.21	335.55	29.43
T_2- $MnSO_4$ @ 25kgha^{-1}(SA)	3.66	10.48	5.08	262.06	22.98
T_3 - $FeSO_4$ @ 25kg ha^{-1}(SA)	4.21	12.19	6.15	298.77	26.14
T_4- $ZnSO_4$ @ 25kg ha^{-1}(SA)	4.39	12.83	6.51	310.86	27.25
T_5- Borax @ 0.5 % (FA)	4.03	11.64	5.80	285.91	25.07
T_6- MnSO4 @ 0.5 % (FA)	3.57	10.27	4.87	255.99	22.73
T_7- $FeSO_4$ @ 0.5 % (FA)	3.85	11.12	5.43	274.01	24.00
T_8- $ZnSO_4$ @ 0.5 % (FA)	4.56	13.45	6.86	323.29	28.31
T_9-Control (Without micronutrients)	3.38	9.31	4.52	244.23	21.45
S. Ed	0.07	0.22	0.11	5.35	0.41
CD(p=0.05)	0.16	0.46	0.23	11.35	0.87

SA- Soil application, FA- Foliar application two sprays at 60 and 90 days after planting.

CHALLENGES AND STRATEGIES FOR INDIA'S SUSTAINABLE DAIRY FARMING

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Abstract

Dairy farming has changed from being merely an agrarian way of life and significant supplementary source of income for many rural Indian families. Due to varying agro-climatic conditions, people's socioeconomic level, the types/breeds of dairy cattle raised, etc., dairy farming has sustainability issues. The most frequent obstacles to sustainable dairy farming include a lack of fodder and/or land for its cultivation, excessive chemical use in agricultural and animal husbandry practises, a lack of knowledge about animal diseases and methods for preventing and controlling them, unhygienic milk production methods, GHG emissions, marketing issues, etc. The best practises for sustainable dairy farming include good animal husbandry procedures like deworming, vaccination, and prevention and control of diseases as well as feeding practises like making efficient use of the feed resources by reducing feed losses, expanding the feed resource base, improving fodder availability and increasing nutrient availability.

Keywords: *Dairy farming, sustainability, challenges, strategies, Greenhouse gases, milk*

Introduction

Milk and milk products is an excellent source of protein, vitamins and minerals, particularly calcium, vitamin D, vitamin A, magnesium and zinc. It has an important role in teeth and bone health. Drinking milk and dairy products may prevent osteoporosis and bone fractures and even help you maintain a healthy weight. Research has shown Osteoporosis, Colorectal cancer, high Blood pressure and Type 2 diabetes can be prevented when low fat dairy products consumed daily.

Sustainable dairy farming is a need of the hour. In India, cow and buffalo are the backbone of dairy industry. Dairy farming has been passed down from generation to generation for centuries. This custom started to fade in the latter part of the 20th century. However, significant progress has been made as a result of scientific and technological developments. The contribution Amul made in the form of the "White Revolution" was crucial in elevating India's dairy sector to a global leader.

More than 290 million dairy cows produced about 700 million tonnes of milk in 2018 [De Vries Marion *et al*. 2019]. India has about 50 million dairy cows (17.6% of the world's dairy cow population), making it the country with the most dairy cows (Table 1 & 2).

Sustainable dairy farming in India

The idea of sustainable dairy farming in India envisions the wise and effective use of resources without over-exploitation. It is crucial to realize that an agricultural system's economic, environmental, and social sustainability all depend on effective management [PPsDairy., 2009].

Sustainable Farming Systems

- When choosing animal breeds, take the farm's layout and the surrounding environment into account.
- Prevent pathogens from entering the farm.
- Put in place an effective herd health/disease management programme.

- Follow the directions on all prescription medications and chemicals to avoid chemical residues in milk.
- Make sure that milking procedures don't harm animals or contaminate the milk.
- Perform milking tasks in a clean environment.
- After milking activities, handle milk carefully.
- Provide enough food and water for all animals, together with healthy and suitable items.
- Manage the feed storage environment properly.
- Ensure the traceability of feeds purchased off-farm.
- Ensure that no animals are starving, thirsty, or undernourished.
- All animals must be free from discomfort, agony, damage, and sickness.
- They must also be free from fear and anguish.
- All animals must also be allowed to act in accordance with their natural instincts.

Economic sustainability

- Ensure the products' transparency, safety, and quality throughout all stages of manufacture and storage.
- Make an effort to stabilize farm revenue over the long term so that it can be used for labour wages and wise investments.
- To maximise benefits, organise yourself and choose effective trading channels.
- To boost farm income and lower risk related to changes in market price, try to diversify the farm into other agricultural operations or/and other non-farming enterprises, as suitable.

Social Sustainability

- Offer a friendly and enjoyable work atmosphere that is devoid of all forms of discrimination and disciplinary measures.
- Sanitary, housing, and transportation infrastructures and services are accessible to farm employees and their families (where applicable).
- Ensure that local and national legislation are followed in regards to the working hours of employees. While reasonable, overtime worked during the busy season must be fairly compensated.
- Ensure that the minimal requirements of local and federal law are met with regard to the pay and benefits that employees receive.
- Ensure that working conditions are in accordance with occupational health and safety recommendations.

Environmental sustainability

- Maintain good soil fertility while avoiding environmental damage, soil erosion, and pollution.
- Manage and use water efficiently.
- Maintain or improve the farm's biological diversity.
- Preserve or enhance air quality.
- Reduce negative effects on the environment and climate change
- Use energy resources wisely and with care.
- Make the most of crop by-products on the farm.
- Recycle any leftover farm waste.

Table:1 Livestock population in India

Species	**1951**	**1992**	**1997**	**2003**	**2007**	**2012**	**2019**
Cattle	155.3	204.6	198.9	185.2	199.1	190.9	192.5
Adult Female Cattle	54.4	64.4	64.4	64.5	73.0	76.7	81.4
Buffalo	43.4	84.2	89.9	97.9	105.3	108.7	109.9
Adult Female Buffalo	21.0	43.8	46.8	51.0	54.5	56.6	55.0
Total Bovines	198.7	288.8	288.8	283.1	304.4	299.6	302.3

Source : Livestock Censuses, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture & Farmers' Welfare, GoI

Table: 2 Milk production and per capita availability in India

Milk production and per capita availability of milk in India (gms/day)		
Year	**Production (Million Tonnes)**	**Per Capita Availibilty**
2002-03	86.2	224
2003-04	88.1	225
2004-05	92.5	233
2005-06	97.1	241
2006-07	102.6	251
2007-08	107.9	260
2008-09	112.2	266
2009-10	116.4	273
2010-11	121.8	281
2011-12	127.9	290
2012-13	132.4	299
2013-14	137.7	307
2014-15	146.3	322
2015-16	155.5	337
2016-17	165.4	355
2017-18	176.3	375
2018-19	187.7	394
2019-20	198.4	406

Source: Basic Animal Husbandry Statistics, DAHD&F, GoI

Challenges in sustainable dairy farming

Over the past three decades, India has quickly risen to become one of the world's largest milk producers, producing 18.5% of the world's milk. However, weaknesses in our dairy supply chain present a severe health concern that must be swiftly fixed. The difficulties in producing sustainable dairy products in India are caused by

- Agro-climatic condition
- Biodiversity, and ecology
- Individuals' socioeconomic and cultural backgrounds
- Breeds and types of dairy cow grown

Fodder and feed: This is a difficult task, especially in light of the following factors: a) population growth; b) shrinking arable land for crop production; c) water scarcity; d) competition between food, feed, and fuel; e) limited phosphorus supply; f) frequent climate extremes; g) rising risks to human and animal health; and h) economic instability.

Productivity and animal health: Increasing farm animal productivity is one of the main challenges. The average yearly milk production of cow in India is approximately 1172 kg, or around 50% of the world average. Infections like Black Quarter, Influenza, and other recurrent outbreaks continue to have a negative impact on livestock health and output.

Greenhouse gas emissions: It is estimated that dairy production systems account for around 30% of all anthropogenic greenhouse gas (GHG) emissions, with global animal production accounting for 14.5% of all GHG emissions (2.1 gigatonnes of CO_2e per year). Future dairy product demand is forecast to rise globally, with India expected to produce the majority of the additional milk. GHG emissions are anticipated to significantly increase in response to this development. Methane is produced by dairy animals through enteric fermentation, and methane and nitrous oxide are produced from manure. In addition to this, dairy production also contributes to increased emissions through land use change, processing, and transportation. Poor herd management, limited access to credit, and a lack of high-quality feed sources are some examples of common constraints that contributes to GHG emissions

Strategies for sustainable dairy farming in India

Feeding strategies:

Increased efficiency in diet formulation will help increase the sustainability of dairy farming. Where fed in excess, protein has potential to be lost as ammonia and nitrous oxide, two damaging GHG’s. This not only results in a negative environmental impact, but a financial loss to the dairy farm.

Making efficient use of available feed resources by:

• Establishing national feed inventories through infrastructure and institutional support

• Putting into practice the idea of providing balanced food in the field and

• Integrating quality assurance practices in feed analysis labs.

Reducing feed losses by:

• Taking field crop leftovers and transforming them into densified complete feed blocks.

• promoting the use of total mixed rations, silage-making techniques, and forage-chopping techniques;

• Making use of the right post-harvest technologies to stop losses brought on by mycotoxins.

Enlarging the feed resource base by:

- The use of co-products from the biofuel industry and research into their effective usage;
- The scaling up of effective detoxification methods from laboratory to pilot and industrial stages;
- The promotion of forages such moringa leaves, thornless cactus, azolla, and winter barley; and
- Leveraging local expertise to find less well-known feeds suitable to tough environments and developing commercial plans to leverage them.

Enhancing the supply of fodder

The development of common land to produce fodder; strengthening certified fodder seed production and marketing systems, including enlisting the help of the corporate sector; strengthening extension and training programmes for farmers; and

Enhancing fodder production includes adding strategically placed oilseed meals/cakes to low-quality roughages and using hydroponically grown fodder to produce year-round supplies of fresh green feed with the least amount of labour, land, water, and space. It is one of the cutting-edge technologies that has been widely accepted throughout the world and has shown to be the most practical and simple technology to use for enhancing farm animals' growth and reproduction.

For sustainable dairy production, farmers can be encouraged to use ration balancing programmes (RBP), compound cattle feed, bypass protein feed, mineral mixtures, and urea molasses mineral blocks.

When there is a lack of green fodder, cattle are fed with silage and hay, which have been conserved or stored. Silage is without a doubt incredibly beneficial for dairy cattle, particularly during dry seasons.

Increasing the use of agro-industrial waste products as animal feed rather than those that compete with human meals.

Environmental strategies:

Healthy soils are one of our greatest resources and will be crucial to the development of sustainable agriculture in the future. Every year, a soil test is conducted at the farm to promote soil health. Then, depending on the current soil fertility, a Nutrient Management Plan can be prepared, outlining the crop nutrient requirements. From both an environmental and a financial standpoint, it is crucial to maximise the efficiency of slurry use through LESSE (Low Emission Slurry Spreading Equipment) and fertiliser use through Nutrient Management Planning.

Animal Husbandry strategies:

Animals with better health will inevitably produce more effectively. Deworming, ectoparasite prevention and control, and prompt vaccination for all diseases with a significant economic impact should all be part of good management practices.

When an animal is physically and physiologically ready to give birth to a calf, breeding may be permitted at younger ages. Calving early enhances an animal's performance throughout its lifetime, reduces lifetime GHG emissions per litre of production, and reduces the carbon footprint of milk.

Integrated Crop–Livestock Farming:

Dairy production has been identified as a major source of greenhouse gas emissions in integrated crop-livestock farming. Using the proper fertiliser and manure applications, integrated

crop-livestock systems (ICLSs) can improve C, N, and P cycling while reducing greenhouse gas (GHG) emissions and water pollution. Animals may be grazed on crops and agricultural residues, forage cover crops may be planted, and farms may exchange crop products and animal waste. With reduced reliance on external input, ICLSs have a higher potential to emulate the structure and operation of natural ecosystems (Segerkvist *et al*. 2020)

Greenhouse Gas mitigation strategies

Even though absolute emissions per animal rise, increasing milk yield per cow is regarded as a promising technique for lowering emissions intensity (emissions per unit of milk output). This tactic works particularly well for small-scale dairy farms in India, where it can also significantly improve the livelihood of underprivileged farmers. Improved herd management is necessary to increase milk yield because it combines feed quantity and quality, animal health, cow fertility, and genetic improvement.

Because of this, additional mitigation strategies should be considered, such as better manure management, low-emission crop cultivation (e.g., effective nitrogen uptake, soil carbon sequestration), and avoidance of land use change. The precise characteristics of the dairy farming systems that are being targeted, as well as their agro-ecological and socioeconomic context, determine the potential effectiveness and acceptability of mitigation approaches.

Conclusion

Of all the animal products, milk is the healthiest to consume. The world's greatest population of livestock is found in India. In India, dairy farming has changed from being merely an agrarian way of life to becoming a professionally run sector. Dairy farming is a significant supplementary source of income for many rural Indian families, who are involved in it. Due to varying agro-climatic conditions, people's socioeconomic level, the types/breeds of dairy cattle raised, etc., dairy farming has sustainability issues. The most frequent obstacles to sustainable dairy farming include a lack of fodder and/or land for its cultivation, excessive chemical use in agricultural and animal husbandry practices, a lack of knowledge about animal diseases and methods for preventing and controlling them, unhygienic milk production methods, GHG emissions, marketing issues, etc. The best practices for sustainable dairy farming include good animal husbandry procedures like deworming, vaccination, and prevention and control of diseases as well as feeding practices like making efficient use of the feed resources by reducing feed losses, expanding the feed resource base, improving fodder availability, increasing nutrient availability from intestinal tracts, and placing more emphasis on ruminant production.

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CURRENT STATUS OF ERICULTURE IN TAMIL NADU

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Abstract

Ericulture being to emerge as a good entrepreneurship source in Tamil Nadu in the past few years. The reason behind this growth is cropping area oferi food plant, tapioca in 91.51 ha and traditional practice followed by the tapioca growing farmers (Removal of leaves at 6 MAP for tuber yield enhancement) as it gives the double income. In addition to this subsidy supported the government attracts the farmers towards ericulture in Tamil Nadu. Undoubtfully, in future our state will raise the eri silk production of the country.

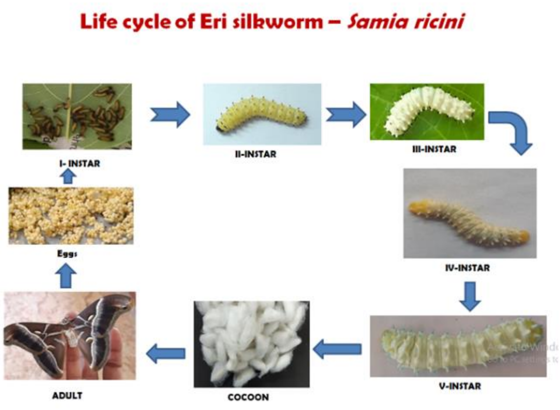
Keywords: Ericulture – tapioca growers – Double income

Introduction

Rearing of eri silkworm is called asericulture. India is the only country which produces all the four types of silk i.e., Mulberry, Eri, Muga and Tasar, out of which eri silkworm is the only non – mulberry silkworm which is completely domesticated. Our country contributes more than 90 per cent (7,359 MT) of world's eri silk production (CSB, 2022). Eri silkworm is polyphagous in nature and its host plants includescastor, kesseru and secondary host plants which include tapioca. Rearing of eri silkworm is traditional practice in North – east India particularly Assam, there eri pupae is also used as food as it is rich in protein and essential amino acids. Southern states of India particularly in Tamil Naduericulture gains popularity slowly among farmers as state sericulture department give subsidy as like for mulberry silkworm since 2019.

Biology of Eri Silkworm

Eri Silkworm, *Samiaricini* Donovan has five larval instars and moult four times. First three larval instars take each 2 – 3 days to grow, fourth larval instar take 4 – 5 days and fifth instar takes 5 – 7 days to develop. Between each instar it goes to moultingfor the period 24 – 36 hours depending on the weather condition.



Special characters and advantages of Eri over mulberry silkworm

- When compare to mulberry silkworm, eri silkworm is resistant to diseases, hardy in nature and easy to handle and rear.
- It constructs open ended cocoon, hence its silk is not reelable. Stifling process is not necessary as the adult emerge from the exit hole. Hence it is called as Ahimsa silk.
- Short larval duration of 18 – 22 days where in case of mulberry it is about more than 25 days.
- In Tamil Nadu, few districts like Salem, Dharmapuri and Erode are important tapioca cultivating areas. As tapioca is the secondary host of eri anditgives almost growth equivalent compared to castor in terms of economic parameters (Matured larval weight, Cocoon weight etc.,). So, the farmers may also rear by using the pruned leaves of tapioca (as it is traditional practice in the state at 6 months after planting a crop to enhance the tuber yield) and get some additional income.

Present status of ericulture in Tamil Nadu:

Tamil Nadu state government initiate the subsidy for rearing of eri silkworm on commercial basis from 2019 onwards for the scheduled caste and tribals only. From 2020 onwards, subsidy has been planned to give to all other communities. For scheduled caste and tribals it about Rs. 4500 for castor plantation/acre and Rs. 90,000 for the construction of the rearing shed, for other castes it is about Rs, 3700 for castor plantation/acre and Rs. 55,000 for the rearing shed (Primary data collected from technical officer, Thiruvannamalai district sericulture department, Tamil Nadu). At present, more than 250 farmers are ready to rear the eri silkworm as they raise the castor plantation of more than half acres.

Future scope of ericulture in entrepreneurship

In Tamil Nadu, total area under tapioca cultivation is 91.51 ha (Indiastat, 2020-2021). Fasae*et al.* (2009) reported the leaf yield of tapioca is 925kg/ha. To rear 100 DFLs of eri silkworm around 1200 kg of leaves is required. From the reported leaf yield of Fasae*et al.* (2009) about 77 DFLsof eri silkworm can be reared and cocoon yield of around 70 kg can be obtained. 1 kg of eri seed cocoon is procured by Eri Silkworm Seed production center, Hosur at the minimum rate of Rs. 400. Hence, approximately around Rs. 30,800 can be earned through ericulture by tapioca growing farmers in Tamil Nadu.

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EFFICIENT RESOURCE CONSERVATION TECHNOLOGY AND FOLIAR FERTILIZATIONEFFECT ON GROWTH, YIELD ATTRIBUTES AND YIELD OF HYBRID MAIZE (*Zea mays* L.)

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Abstract

Soil moisture is one of the important factors that manipulates the growth and yield of the maize crop. It will help to supply soil nutrients to the plant to enhance the growth and yield of the crop. Due to the lack of moisture in the soil, foliar nutrition is very much affected and thus it reflects on the growth and yield of the crop. The field experiment was conducted during 2020 – 21 at Annamalai University Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Chidambaram, Tamilnadu, India to maximize the productivity and profitability of maize by adopting various soil moisture conservation techniques and foliar fertilization. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. The experiment consists of two factors. In factor I, soil moisture conservation techniques were adopted viz., M_1 – Control, M_2 - Sugarcane trash, M_3 - Water hyacinth and M_4 – Hydrogel. In factor II, foliar nutrient management practice was accommodated such as F_1 - control (without nutrient), F_2 - foliar spray of 1% 19:19:19, F_3 - 1% DAP + 1% MOP, F_4 - 1% PPFM, F_5 - 1% 19:19:19 + 1% PPFM and F_6 - 1% DAP + 1% MOP + 1% PPFM. Foliar nutrients were applied at both Knee high and tasseling stages. Among the soil moisture conservation techniques, the results indicated that mulching with Water hyacinth has registered higher growth parameters, yield parameters and yield than other techniques. Whiledifferent foliar nutrients, the foliar application of 1% DAP + 1% MOP + 1% PPFM (F_6) shown higher growth, yield parameters andyield than other treatments. With respect to integration of soil moisture conservation techniques and foliar nutrients, mulching with Water hyacinth andfoliar application of 1% DAP + 1% MOP + 1% PPFM (M_3F_6) recorded higher growth, yield parameters and yield than the rest of the treatment combinations.

Keywords: *Maize, Soil Moisture Conservation, Foliar fertilization, PPFM.*

Introduction

Among the cereals, Maize crop has been ranked atthe third-place after wheat and rice, globally (Olaniyan, 2015) As a matter of fact, the maize germination rate is reduced under drought stress conditions due to low water absorption and decline in the metabolic enzymatic activation (Ghorbani and Nez-had, 2012). Maize is very sensitive to drought at different growth stages from germination to maturity. In the development growth stages of maize, moisture stress affects cell division and cell proliferation (Muhammad *et al.*, 2015), while in the reproductive stage drought affects tassel, embryo, endosperm development, ear, pollination, fertilization, grain filling and results in loss of crop yield (Du Plessis, 2003). Bhardwaj (2013) reported that mulching has various beneficial effects on crop production in arid and semi-arid regions including increase in soil moisture (4.7-12.5%), reduction in the run off (30- 70.5%), soil erosion (70-85%), weed growth

(90-95%), pest control (15.0- 27.35%), maintaining soil temperature (0.5C to 7.0°C higher), increase in the plant growth (12.3-26.9%), development (23-37%) and quality of the produce (7.5-22%) and also promotes earlier harvest of the crop (7-15 days).

In the study area of Cauvery delta zone, during the Kharif season rice cropfit well in the first season of the cropping year and cultivated every year from June onwards by utilizing Cauvery River water and South West monsoon rains. Delay in the onset of monsoonlead insufficient filling of the reservoirand availability of water that caused uncertainty about the time of water release from Mettur dam (reservoir) and reduced duration of water availabilityconsequently affects the rice cultivation during kharif season. In this grievous situation, cultivation of maize offered assured economic return to the farmers instead of leaving the land as fallows during kharif season due to late receipt of irrigation water in the tail end Cauvery deltaic zone of Tamilnadu (Thiruppathi, 2017). However, the yield of maize is very low against its potential yield due to low level of available soil moisture during cropping period in the tail end cauvery deltaic regions.

Among the methods of fertilizer application, foliar nutrition is recognized as an important method of fertilizationunder limited soil moisture condition because foliar nutrients penetrate the leaf cuticle or stomata and enter the cells facilitating easy and rapid utilization of nutrients without much loss. Hence, it is the fastest way to boost crop growth (Latha and Nadanassababady, 2003). It is also an effective method for correcting nutrient deficiencies and overcoming the soil's inability to transfer nutrients to the maize plant under low moisture conditions (Stigler *et al.*, 2010). Supplemental foliar application of major and micronutrients is more advantageous than soil application due to better translocation from the leaves to the developing seeds and efficient utilization of nutrients (Manonmani and Srimathi, 2009).

Keeping these in view, the present field experiment was planned to develop remunerative, productive, and cost-effective agronomic approach for hybrid maize grown under limited moisture supply.

Materials and Methods

The field experiment was conducted at Annamalai University Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Chidambaram, and Tamilnadu, India during 2020 – 21. Geographically this area is situated at 11° 24' N latitude, 74° 41' E longitude, with an altitude of +5.79 m above mean sea level and 15 km away from the East coast of Bay of Bengal. The mean annual rainfall receives 1541 mm with a distribution of 1061 mm during North-East monsoon (Oct-Dec), 244 mm during South - West monsoon (June-Sep), 53 mm during winter (Jan & Feb) and 183 mm as summer showers (March-May) spreading over 52 rainy days. The mean relative humidity is 87 per cent. The soil of the experimental field is the representative of the Cauvery delta region. The soil is moderately clay with a pH of 7.08. The maize hybrid Dhanvi 166 is used as test crop and dibbled by adopting a spacing of 60 x 20 cm. The treatment was laid out in factorial randomized block design and consisted of two factors with three replications *viz.*, In factor I, soil moisture conservation techniques were adopted *viz.*, M_1 – Control, M_2 - Sugarcane trash at 10 t ha^{-1}, M_3 - Water hyacinth at 12 t ha^{-1} and M_4 – Hydrogel 10 kg ha^{-1}. In factor II, foliar nutrient management practice was accommodated such as F_1 - control (without nutrient), F_2 - foliar spray of 1% 19:19:19, F_3 - 1% DAP + 1% MOP, F_4 - 1% PPFM, F_5 - 1% 19:19:19 + 1% PPFM and F_6 - 1% DAP + 1% MOP + 1% PPFM. The foliar nutrients were applied at knee-high and tasseling stages. N, P_2O_5 and K_2O were supplied through urea, single superphosphate, and muriate of potash, respectively. The data onplant height at harvest, dry matter production at harvest, number of cobsplant^{-1}, number of

rowscob^{-1}, number of grainscob^{-1}were observed the five tagged plants and the average values of each treatment was calculated and tabulated. The yield was calculated from the net plot area and the produce was cleaned, weighed, and expressed in terms of kgha^{-1}. The statistical analysis of the field data was carried out as per the methodology by Gomez and Gomez (2010) The critical differences were worked out at 5 per cent probability level, wherever the results were significant.

Results and Discussion

Growth parameters

The data on plant height and dry matter production presented in table 1. Different soil moisture conservation approaches and foliar fertilization exhibited significant effect on plant height and dry matter productionof hybrid maize.

Among the different soil moisture conservation techniques, the plot receiving water hyacinth mulch at 12 t ha^{-1} (M_3) registered the maximum plant height of 207.38cm and dry matter production of 13580kg ha^{-1}. This was followed by application of hydrogel at 10 kg ha^{-1} (M_4). The lowerplant heightof 165.82 cm and dry matter production10624 kg ha^{-1}were recorded in control (M_1).

Irrespective of the different foliar nutrition treatments, foliar application of 1% DAP + 1% MOP + 1% PPFM (F_6) recorded maximum plant height of 215.46cm and dry matter production of 14060 kg ha^{-1}. The least plant heightof 164.95 cm and dry matter production10832 kg ha^{-1} were recorded in control (F_1).

Integration of soil moisture conservation techniques and foliar nutrition showed significant effect on plant height and dry matter production. The results revealed that mulching the soil with water hyacinth and foliar application of 1% DAP + 1% MOP + 1% PPFM with RDF (M_3F_6) has recorded maximum plant height of 238.17cm and dry matter production of 15473kg ha^{-1}. The lowerplant heightof152.64cm and dry matter productionof 9407kg ha^{-1} recorded in control (M_1F_1). The increased plant height and dry matter production over water hyacinth mulch might be due to availability of soil moisture through its storage and foliar nutrient, which led to the production of higher yield. The parallel results were reported by Dennis *et al*. 2018.

Yield parameters

The data on number of cobs plant^{-1}, number of rows cob^{-1}, number of grains row^{-1}, test weight furnished in table 2and 3. Different soil moisture conservation approaches and foliar fertilization exhibited significant effect on number of rows cobs^{-1} and number of grains row^{-1} in hybrid maize. However, number of cobs plant^{-1} and test weight were not significantly affected by soil moisture conservation approaches and foliar fertilization.

Among the different soil moisture conservation techniques, the plot receiving water hyacinth mulchat 12 t ha^{-1} (M_3) registered the maximum row number of 16.90cob^{-1}and grain number of 20.22 row^{-1}. This was followed by application of hydrogel at 10 kg ha^{-1} (M_4). The least number of rows cob^{-1}(15.16) and grain number row^{-1} (17.63) were recorded in control (M_1).

Irrespective of the different foliar nutrition treatments, foliar application of 1% DAP + 1% MOP + 1% PPFM (F_6) recorded maximum row number of 17.54 cob^{-1} and grain number of 20.17 row^{-1}. The least number of rows cob^{-1}of 15.27 and grain number row^{-1}17.92 were recorded in control (F_1).

Integration of soil moisture conservation techniques and foliar nutrition showed significant effect on number of rows cob^{-1} and grain number row^{-1}. The results revealed that mulching the soil with water hyacinth and foliar application of 1% DAP + 1% MOP + 1% PPFM with RDF (M_3F_6)

has recorded maximum row number of 18.72 cob^{-1} and grain number of 20.82 row^{-1}. The least number of rows cob^{-1}were 15.01 and grains row^{-1} were 16.06 recorded in control (M_1F_1). The increased number of rows cob^{-1} and grains row^{-1} over water hyacinth mulch was probably due to supply of soil moisture through its conservation mechanism and foliar nutrient, which led to the production of higher yield. Foliar spray of 1% of DAP, MOP and PPFMB at knee high and tasseling stages have helped in contribution of more quantum of assimilates to reproductive organs to produce higher number of rows cob^{-1} and grains row^{-1}. The parallel results were reported by Parvin Akter Bithy *et al.* (2020).

Grain and Stover yield

The data on grain yield and stover yield furnished in table 4. Different soil moisture conservation approaches and foliar fertilization exhibited significant effect on grain yield and stover yield.

Among the different soil moisture conservation techniques, the plot receiving water hyacinth mulch at 12 t ha^{-1} (M_3) registered the grain yield of 5650 kg ha^{-1} and stover yield of 9447 kg ha^{-1} This was followed by application of hydrogel at 10 kg ha^{-1} (M_4). The least grain yield (4064 kg ha^{-1}) and stover yield (7731 kg ha^{-1}) were recorded in control (M_1).

Irrespective of the different foliar nutrition treatments, foliar application of 1% DAP + 1% MOP + 1% PPFM (F_6) recorded the grain yield of 5906 kg ha^{-1} and stover yield of 9711. The least grain yield of 4176 kg ha^{-1} and stover yield of 7858 were recorded in control (F_1).

Integration of soil moisture conservation techniques and foliar nutrition showed significant effect on grain yield and stover yield. The results revealed that mulching the soil with water hyacinth and foliar application of 1% DAP + 1% MOP + 1% PPFM with RDF (M_3F_6) has recorded higher grain yield of 6618kg ha^{-1}and stover yield of 10479 kg ha^{-1}. The least grain yield recorded was 3412 kg ha^{-1} and stover yield was 7033 kg ha^{-1}were recorded in control (M_1F_1). The use of water hyacinth mulch leads to increased moisture retention capacity of soil due to lesser evaporation, reduced the soil temperature, improved microclimate above and below the soil surface and timely application of foliar nutrients thus helped to attain higher yield. The similar findings were concorded with Sharda and Lakshmi (2014).

Conclusion

From the present field experiment it can be concluded that mulching the soil with water hyacinth andapplication of 1% DAP plus 1% MOP plus 1% PPFM with RDF (M_3F_6) has found to be effective practice for getting higher yield and economic benefit to the maize farmers during kharif season.

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Table. 1 Effect of soil moisture conservation and foliar fertilization techniques on number of plant height (cm)and dry matter production (kg ha^{-1}) of hybrid maize

Treatments	Plant height (cm)							Dry matter production (kg ha^{-1})						
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**Mean**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**Mean**
M1	152.64	166.86	166.91	166.21	170.09	172.19	**165.82**	9407	10481	10558	10418	11423	11459	**10624**
M2	167.01	184.21	196.85	168.03	211.28	224.85	**192.04**	11135	12081	12849	11278	13751	14595	**12615**
M3	171.11	198.95	212.32	197.91	225.84	238.17	**207.38**	11451	13144	13832	12978	14602	15473	**13580**
M4	169.05	185.21	210.31	183.21	213.51	226.61	**197.98**	11337	12159	13703	12018	13954	14713	**12981**
Mean	**164.95**	**183.81**	**196.60**	**178.84**	**205.18**	**215.46**		**10832**	**11966**	**12735**	**11673**	**13432**	**14060**	

	SEd	CD (p=0.05)	SEd	CD (p=0.05)
M	2.20	4.42	143.22	288.30
F	2.69	5.41	175.41	353.10
M x F	5.38	10.82	350.83	706.20

Table.2 Effect of soil moisture conservation and foliar fertilization techniques on number of cobs plant^{-1} and Number of rows cob^{-1} of hybrid maize

Treatments	**Number of cobs plant^{-1}**							**Number of rows cob^{-1}**						
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**Mean**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**Mean**
M1	1.00	1.00	1.02	1.02	1.02	1.01	**1.01**	15.01	15.14	15.21	15.14	15.35	15.11	**15.16**
M2	1.00	1.02	1.00	1.01	1.00	1.01	**1.01**	15.58	15.51	15.99	15.51	17.05	17.89	**16.25**
M3	1.02	1.00	1.03	1.01	1.02	1.03	**1.02**	15.21	16.05	17.33	15.98	18.11	18.72	**16.90**
M4	1.01	1.00	1.01	1.02	1.02	1.02	**1.02**	15.26	15.64	16.65	15.45	17.54	18.44	**16.50**
Mean	**1.01**	**1.01**	**1.02**	**1.02**	**1.02**	**1.02**		**15.27**	**15.59**	**16.30**	**15.52**	**17.01**	**17.54**	

	SEd	**CD (p=0.05)**	**SEd**	**CD (p=0.05)**
M	NS	NS	0.19	0.37
F	NS	NS	0.23	0.46
M x F	NS	NS	0.46	0.92

Table.3 Effect of soil moisture conservation and foliar fertilization techniques on Number of grains row^{-1}and Test weightof hybrid maize

Treatments	Number of grains row^{-1}							Test weight (100 grain weight)						
	F1	F2	F3	F4	F5	F6	Mean	F1	F2	F3	F4	F5	F6	Mean
M1	16.06	17.31	17.51	17.29	18.58	19.04	**17.63**	19.21	21.15	20.85	20.65	21.01	21.49	**20.73**
M2	18.29	19.63	20.54	18.32	20.31	20.61	**19.62**	21.25	21.78	22.31	21.36	23.05	23.15	**22.15**
M3	18.75	20.65	20.12	20.78	20.21	20.82	**20.22**	21.21	22.81	22.35	22.19	23.13	23.65	**22.56**
M4	18.58	19.85	21.05	19.41	20.05	20.21	**19.86**	21.55	21.95	22.59	21.58	22.98	23.15	**22.30**
Mean	**17.92**	**19.36**	**19.81**	**18.95**	**19.79**	**20.17**		**20.81**	**21.92**	**22.03**	**21.45**	**22.54**	**22.86**	

	SEd	CD (p=0.05)	SEd	CD (p=0.05)
M	0.22	0.45	NS	NS
F	0.27	0.55	NS	NS
M x F	0.55	1.10	NS	NS

Table 4. Effect of soil moisture conservation and foliar fertilization techniques on Grain yield (kg ha^{-1}) and Stover yield (kg ha^{-1}) of hybrid maize

Treatments	Number of grains row^{-1}							Test weight (100 grain weight)						
	F1	F2	F3	F4	F5	F6	Mean	F1	F2	F3	F4	F5	F6	Mean
M1	16.06	17.31	17.51	17.29	18.58	19.04	**17.63**	19.21	21.15	20.85	20.65	21.01	21.49	**20.73**
M2	18.29	19.63	20.54	18.32	20.31	20.61	**19.62**	21.25	21.78	22.31	21.36	23.05	23.15	**22.15**
M3	18.75	20.65	20.12	20.78	20.21	20.82	**20.22**	21.21	22.81	22.35	22.19	23.13	23.65	**22.56**
M4	18.58	19.85	21.05	19.41	20.05	20.21	**19.86**	21.55	21.95	22.59	21.58	22.98	23.15	**22.30**
Mean	**17.92**	**19.36**	**19.81**	**18.95**	**19.79**	**20.17**		**20.81**	**21.92**	**22.03**	**21.45**	**22.54**	**22.86**	

	SEd	CD (p=0.05)	SEd	CD (p=0.05)
M	0.22	0.45	NS	NS
F	0.27	0.55	NS	NS
M x F	0.55	1.10	NS	NS

BACTERIOCIN PRODUCTION BY A NEW ISOLATE OF *Pediococcus pentosaceous* UNDER DIFFERENT CULTURE CONDITIONS

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Abstract

Bacteriocins have attracted much attention in the field of bio preservation and human therapeutics. Therefore, a study was carried out to isolate a bacteriocin producing lactic acid bacteria from the idly batter using MRS medium. The bacteriocin producing organism was identified as Pediococcus pentosaceus LABI1 by standard morphological, biochemical, and physiological methods. The bacteriocin produced by the isolate was active against food borne pathogens, among the four bacterial isolates LABI1 was showed highest antibacterial activity among the test organisms examined. Optimizing the culture conditions for higher growth and production of bacteriocins by the isolate of Pediococcus pentosaceous LABI1. Optimization was carried out by altering the initial pH, temperature, Nacl concentration, different concentrations (10 to 40 g/L) of carbon sources, glucose, and lactose employed in the production of bacteriocin. The isolate of Pediococcus pentosaceous LABI1showed highest growth and bacteriocin activity was recorded at pH 7.0, 37°C and in the absence of Nacl. The isolates showed optimum growth and activity in the presence of 20 g/L glucose and 40 g/L lactose. In comparison to glucose, the growth and activity were less in the presence of lactose.

Keywords: *Antimicrobial Activity, Bacteriocin, Optimization, Pediococcus pentosaceus LABI1*

Introduction

The microbiology of many fermented foods is quite complex and yet to be explored in a greater way. The microbial fermentation process improves the shelf life, texture, taste, and aroma of the final products. These properties aid as bio preservatives in the food industries (Blandino *et al.,* 2003). Indigenous fermented foods have been prepared and consumed for thousands of years. They are strongly linked to culture, traditions and reveal the intellectual richness of indigenous people of the country in terms of their ability to prepare microbial products for varied purposes in addition to food and beverages (Sekar and Mariappan, 2007). However, the preparation of indigenous or "traditional" fermented foods and beverages remain as a household art even today (Larry and Beuchat, 2008).

Lactic Acid Bacteria (LAB) have been used to ferment or culture foods for at least 4000 years. A wide variety of strains are routinely employed as starter cultures in the manufacture of dairy, meat, vegetable, and bakery products.

One of the most important contributions of these microorganisms is the extended shelf life of the fermented product by comparison to that of the raw substrate. Growth of spoilage and pathogenic bacteria in these foods is inhibited due to competition for nutrients and the presence of starter-derived inhibitors such as lactic acid, hydrogen peroxide and bacteriocins (Ray and Daeschel, 1992). Bacteriocins become one of the weapons against microorganisms due to the

specific characteristics of large diversity of structure and function, natural resource, and being stable to heat. Therefore, bacteriocins may become a potential drug candidate for replacing antibiotics in order to treat multiple drug resistance pathogens in the future (Yang *et al.,*2014). These bacteriocins are antibacterial proteins vary in spectrum of activity, mode of action, molecular weight, genetic origin and biochemical properties. These substances are produced by various gram-positive and gram-negative bacteria (Moreno *et al.*, 2000). During the past years, antimicrobial compounds produced by Lactic Acid Bacteria (LAB) have been subjected to intensive study because of their potential use for the manufacture of wide variety of traditional fermented foods (Nettles and Barefoot, 1993). Increasing number of reports on new/novel bacteriocins with unique properties indicate that there is still a large scope to learn about this family of peptide antibiotics. These antimicrobial peptides have huge applications in food preservation and in next-generation antibiotics targeting the multiple drug resistant pathogens. The unique properties like thermal stability, pH tolerance and no reports on the development of resistant bacteria, made bacteriocins a potential molecule (Perez *et al.,* 2014). Even though bacteriocins are good in controlling the food-borne pathogens, they are naturally safe by losing their activity due to the cleavage of bacteriocins due to gastrointestinal (GI) tract protease (Saavedra *et al.,* 2004) In the present study, LAB has been isolated from Idly batter a legume-based fermented food in India. The essential microbes responsible for fermentation are found to be naturally present in the ingredients Thus, the objective of this study is to isolate and identify LAB from idly batter exhibiting wide spectrum of antimicrobial activity and optimization of culture conditions for bacteriocin production.

Materials and Methods

Isolation and screening for antimicrobial activity

LAB was isolated from idly batter, after serial dilutions with 0.85% saline, plated on MRS agar and incubated anaerobically. White clear elevated colonies were selected, and pure cultures were stored in MRS broth with 30% (v/v) glycerol at -20ºC. Indicator organisms used in this study were procured from the Microbial Type Culture Collection (MTCC) from the Institute of Microbial Technology, Chandigarh (Table - 1), maintained and propagated in MRS and Soyabean Casein digest broth. The isolates were grown in MRS broth and antimicrobial activity was evaluated by agar well diffusion assay as described earlier (Ray and Daschel, 1992). Isolates inhibiting various food borne pathogenic microorganisms (Table - 1) were considered as potent isolates and selected for further characterization studies. The antimicrobial substance was treated with 3mg/ml of protease in 10mM citrate buffer pH 3.0 (Sigma, India) and the activity was evaluated against *Staphylococcus aureus* (Moraes*, et al,.*2010) The control was also processed in similar way without enzyme.

Physiological and biochemical characterization

Bacterial Strain LABI1was isolated from idly batter and identified as *Pedeiococcus pentosaceus* based on growth on selective MRS agar, cell morphology, gram staining, catalase activity, homo–hetero fermentation and biochemical identification of LABI1. Further identification of the species of these LABI1 was performed according to carbohydrate fermentation patterns and growth on MRS broth (HI Media) as described in Bergey's manual of systematic bacteriology. The isolated LABI1 were sub cultured and the purified cultures maintained at MRS agar slants. MRS medium (HI Media) was used for all experiments, except in growth optimization in which case modified MRS broth (De Man *et al.,* 1960) was used.

Bacterial Strains and Growth Conditions

P. pentosaceus LAB I1 was routinely grown and maintained on TGYE agar medium (g/L tryptone 5, glucose 1, yeast extract 3, agar 1.5 %, and pH 7.0) at 37°C (14). MRS broth medium (g/L peptone 10, beef extract 10, yeast extract 5, dextrose 20, polysorbate-80 1, ammonium citrate 2, sodium acetate 5, magnesium sulphate 0.5, manganese sulphate 0.2, di-potassium phosphate 2, pH 6.8) (15) was used to produce bacteriocin. Indicator strain *Listeria monocytogenes* MTCC 657 was grown in the Trypticase soy broth (g/L Tryptone 15 g, Soya peptone 5 g, Sodium chloride 5 g.

Preparation of Cell-Free Supernatant and Determination of Antimicrobial Activity

Bacteriocins are secreted in cell-free supernatant (CFS) during the growth of bacteria. Therefore, CFS was used to determine the antimicrobial activity. The LABI1 isolates was grown in MRS medium at 37°C in a BOD incubator for 18 hours. The cultures were centrifuged at 10,000 rpm for 15 minutes. After centrifugation, CFS was collected and filter-sterilized with 0.2µm syringe filter (Axiva, India). Agar well diffusion assay (AWDA) was performed as described by Kaur and Tiwari (2016). Briefly, soft nutrient agar (0.8%) medium (5 mL) seeded with 10^6 cells of freshly grown culture of indicator strain *Listeria monocytogenes* MTCC 657 was overlaid on nutrient base agar plate. Wells of 6 mm diameter were cut out with sterile cork borer and CFS (100 µL) was loaded. The plates were incubated at 37°C in a BOD incubator overnight. After incubation, the growth inhibition zone was observed, and diameter was measured in millimetre (mm).

Optimization Conditions for Growth and Bacteriocin Production

pH

MRS medium was set to pH 3 to 10 with 1N NaOH and Hcl. Overnight grown culture of isolate LABI1 was inoculated to an initial OD600 0.02. The sets were incubated at 37°C for 18 hours. The growth was measured using a spectrophotometer at 600 nm and antimicrobial activity of CFS was determined using AWDA as described above.

Temperature

Isolate LABI1wasinoculated in MRS medium to initial OD600 0.02 and incubated at 20,30, 37, 42, and 50°C in a BOD incubator for 18 hours. The growth was measured using a spectrophotometer at 600 nm and antimicrobial activity of CFS was determined using AWDA as described above.

NaCl Concentrations

MRS medium was prepared containing different concentrations of NaCl in different sets from 2% to 10%. The LABI1isolates was inoculated to an initial OD600 0.02 in each set and incubated at 37°C for 18 hours. MRS medium without NaCl was used as control. The growth and antimicrobial activity were detected as described above.

Different Carbon Sources

The effect of different carbon sources on growth and bacteriocin production was studied as described by Vijay Simha *et al*. 2012). MRS medium containing different concentrations of glucose and lactose (10, 20, 30 and 40 g/L) were prepared in different sets and filter-sterilized. These sets were inoculated with LABI1 at an initial OD600 0.02 followed by incubation at 37°C for 18 hours. Growth and antimicrobial activity were determined as described above. MRS medium without glucose or lactose was used as control.

Results and Discussion

Idly an easily digestible food, prepared from fermented batter and steam cooked is the most preferred food in south India. The predominant isolate in this study was *Pediococcus* and

Leuconostoc which could have been possibly obtained from dehulled black gram whereas in earlier reports Lactococcus lactis has been isolated from idly batter (Iyer *et al.,* 2011). This variation may be due to source of batter preparation and season that affect the prevalence of bacteria and yeast in the batter (Soni *et al.,* 1986). Six elevated colonies which were Gram positive, catalase negative, acid producing, cocci were isolated from idly batter. They were grouped into 4 homofermentative and 2 heterofermentative, which were screened for antimicrobial property against various food borne pathogenic organisms. The heterofermentative isolates were not potent hence were not chosen for further studies. A total of 4 homofermentative isolates showed good antimicrobial activity which was lost after treatment with protease thus confirmed bacteriocinogenic property (Moraes *et al.,* 2010). All isolates produce acid from arabinose, ribose, galactose, glucose, fructose, mannose, salicin, cellobiose, maltose, lactose, trehalose, and esculin while none of the isolates produces acid from melezitose, mannitol, raffinose, sorbitol, and xylose. Since they all grow at 15, 45 and 37°C while none grow at 50°C, they are confirmed as *P. pentosaceus* differing at strain level because of variation in their biochemical and physiological characteristics (Table - 1) among the four isolates LABI1 shows higher antibacterial activity so it is used for further study (Table - 2). The production of bacteriocin is an energetic process, which show growth associated phenomenon. Different conditions including carbon source are important to produce bacteriocin. It is reported that antimicrobial activity follows similar patterns of growth curve of most LAB strains (Tiwari *et al., 2008*, Cheigh *et al., 2002*). Therefore, growth was optimized under different conditions such as pH, temperature, different concentrations of NaCl and carbon source

Effect of Different pH

P. pentosaceus LABI1 grew up to OD 600 1.3 to 1.6 and demonstrated antimicrobial activity up 20.5 to 22.0 mm at pH 5.0 to 8.0. The optimum growth of the isolates was at pH 7.0 (OD600 1.6). They grew to very less extent (OD 600 0.2 to 0.3) under highly acidic (pH 3.0 and 4.0) and low antimicrobial activity 4.1mm was recorded at pH3.0 at alkaline (pH 9.0 and 10.0) with no antimicrobial activity conditions was observed. Therefore, extreme conditions were lethal for the growth and activity (Table - 3) The *P. pentosaceus* LABI1 Isolate grew and demonstrated activity at acidic and near neutral pH similar *Lactobacillus casei* and *Lactococuss lactis subsp. lactis* showed optimum growth and bacteriocin production at pH 6.5 to 7.0 (Kumar *et al.,* 2012). *Pediococcus pentosaceus* MTCC 5151 showed optimum activity at pH 5.5 (Agrawal *et al.,* 2012). Pentosaceus NRC AM1 and *P. pentosaceus* NRC AM4 grew well at pH 4.0 to 8.0 (Mabrouk et *al., 2014*) .

Effect of Different Temperatures

Pediococcus pentosaceus LABI1 the highest growth was recorded at 37 °C (OD 600 1.2) and showed the antimicrobial activity 23 mm. The growth at 30 and 42°C were OD 600 1.1 and 0.7, respectively. The lowest activity was recoded at 20°C. Therefore, LAB I1 was sensitive to higher temperatures, at 50°C. Antimicrobial activity demonstrated by these isolates was consistent to growth as shown in (Table - 4) the optimum temperature for the growth of *P. pentosaceus* strains was 28 to 35°C (Papagianni *et al.,* 2009). *P. pentosaceus* NRC AM1 and *P. pentosaceus* NRC AM4 grew well at 10 to 45°C (Mabrouk et *al.,* 2014). The highest bacteriocin production by *P. acidilactici* (Altuntas *et al.,* 2010) and *P. pentosaceous* NCDC 273 was reported at 37°C (Vijay Simha *et al.,* 2012). The growth at wide range of pH and temperature provides extra advantage for the application of isolates and their bacteriocins in different foods.

Effect of Different Concentrations of NaCl

P. pentosaceus LABI1 of the isolate showed highest growth (OD 600 -1.3) and antimicrobial activity (the growth inhibition zone - 21 mm) in the medium without NaCl. The growth of the isolate was continuously decreased as the concentration of NaCl increased. The antimicrobial activities of these isolate also decreased by increasing the concentration of NaCl and reduced to nil at 6% NaCl and above. These isolates could tolerate, grow and produce bacteriocin only with up to 4% NaCl. (Table -5). Similar results were also reported for *P. pentosaceus* NRC AM4 where growth decreased with increase in NaCl concentrations (Mabrouk *et al.,* 2014). *Pediococcus acidilactici* (Altuntas *et al.,* 2010) grew up to 10% NaCl, but grew optimally in the absence of NaCl (Altuntas *et al.,* 2010)). The growth of LAB is sometimes better in the presence of low salt concentration, usually 1% to 2% and is inhibited above 3% NaCl, while few LAB are more resistant to NaCl (Altuntas *et al.,* 2010). Delgado *et al.,* (2007) stated that NaCl was required to maintain osmotic pressure in the cells, but not required to produce bacteriocin.

Effect of Different Carbon Sources

Carbon source is important for growth and affects bacteriocin production, which is a highly energetic process. Therefore, different concentrations of the two most used carbon sources, glucose, and lactose, were supplied in the culture medium, and growth and bacteriocin production were monitored. *P. pentosaceus* LABI1 grew almost equally up to OD 600 1.6 at 20 to 40 g/L of glucose. The Constant production rates of bacteriocin were observed (22 mm growth inhibition zone) at 20% to 40% glucose, but reduced at 10% glucose by 17 mm. *P. pentosaceus* LABI1 isolates demonstrated much less growth (OD 600 - 0.4), and antimicrobial activity was nil when grown in a medium without glucose (Table - 6) In contrast, the growth of *P. pentosaceus* LABI1 was lower at 10 g/L (OD 600 0.5) and 20 g/L (OD 600 1.4) lactose, but increased with increasing the concentration of lactose. It grew optimally up to OD 600 1.6 at 30 to 40 g/L lactose. There was no bacteriocin production up to 20 g/L lactose used in the culture medium and very low antimicrobial activity was recorded at 30 g/L (inhibition zone - 9 mm) Table -7. The optimum activity (growth inhibition zone - 14 mm) was recorded at 40 g/L lactose. In comparison to glucose, growth and bacteriocin production by P. *pentosaceus* LABI1 were lower at similar concentrations of lactose. *P. pentosaceus* LABI1 isolates demonstrated bacteriocin production at 10% to 20% glucose, but it was nil in the presence of lactose at these concentrations. These results suggested that the isolate utilized glucose more efficiently than lactose. Similar observation was reported by Pal *et al.,* 2010) where optimum bacteriocin production by *W. paramesenteroides* DFR8 was higher in the presence of glucose as compared to those of other carbon sources including lactose. Delay in growth and antimicrobial activity by *P. pentosaceous* NCDC 273 in the presence of lactose was also reported by Vijay Simha *et al.,* These findings suggested that the growth and bacteriocin production were higher in the presence of glucose as compared to that of lactose.

Conclusion

The culture conditions were optimized for higher growth and production of bacteriocin by soil isolates *P. pentosaceus* LABI1 and. The optimum growth conditions for bacteriocin production by isolate LB44 was MRS medium supplemented with glucose at pH 7.0 and incubation temperature 37°C. The growth and activity of the isolate was higher in the medium without NaCl. Glucose was more effective than lactose for growth and bacteriocin production. Therefore, optimized culture conditions are useful for higher yield of bacteriocins and their industrial applications.

Table - 1. Physiological and biochemical characteristics of the clustered isolates

Physiological and biochemical characteristics	LABI1	LABI2	LABI3	LABI4
Acetoin production	+	+	+	+
Arginine hydrolysis	+	+	+	+
Growth at pH 9.5	+	-	+	+
Growth at 15°C	+	+	+	+
Growth at 37°C	+	+	+	+
Growth at 45°C	+	+	+	+
Growth at 50°C	-	-	-	-
Salt Tolerance (6.5%)	+	+	+	+ -
Carbohydrate fermentation				
Maltose	+	+	-	+
Galactose	+	±	-	-
Raffinose	+	+	-	-
L- arabinose	+	+	+	+
glucose	+	+	+	+
Ribose	+	+	+	+
Mannose	+	+	+	+
Lactose	+	+	+	+
Xylose	±	±	±	±
Rhamnose	-	-	-	-
Sorbitol	-	-	-	-
Raffinose	±	±	±	±
Fructose	+	+	+	+
Gluconate	-	-	-	-
Trehalose	+	-	+	+
Melibiose	±	±	±	±
Sucrose	-	-	-	±
Mannose	+	+	+	+
Inulin	+	-	-	±
Salicin	+	+	-	-
Melezitose	-	-	-	-

Cellobiose	+	+	-	±
Tentatively identified as	*Pediococcus pentosaceous*	*Pediococcus pentosaceous*	*Pediococcus pentosaceous*	*Pediococcus pentosaceous*

(+) good growth; (±) weak growth;(–) no growth

Table - 2. Antibacterial spectrum of the isolates isolated from Idly batter

Indicator Bacteria	Isolates of Idly batter			
	LABI1	LABI2	LABI3	LABI4
Micrococcus luteus MTCC 106	19	17	14	17
Listeria monocytogenes MTCC 657	22	17	17	15
Bacillus subtilis MTCC 619	20.2	18.3	16.2	14.3
Aeromonas hydrophila MTCC 1739	20.1	16.3	17.3	15.4

Table – 3. Effect of Growth and Antimicrobial Activity of Isolates LAB I1 at Different Ph

Different pH	O.D (600 nm)	Inhibition Zone Diameter (mm)
3	0.25	4.1
4	0.3	5.3
5	1.3	20.5
6	1.5	21.7
7	1.6	22.0
8	1.4	17
9	0.1	-
10	0.1	-

Table – 4. Growth and Antimicrobial Activity of Isolates LABI1Different Temperatures

Temperature(°C)	O.D (600 nm)	Inhibition Zone Diameter (mm)
20	0.6	4
30	1.1	21
37	1.2	23
40	0.7	14
50	0.1	-

Table – 5. Growth and Antimicrobial Activity of Isolates LABI1 at Different Concentrations of NaCl

Different Nacl Concentration	O.D (600 nm)	Inhibition Zone Diameter (mm)
0	1.3	23
2	1.1	20
4	0.7	14
6	0.5	4
8	0.3	3
10	0.2	2

Table – 6. Growth and Antimicrobial Activity of Isolates LABI1 at Different Concentrations of Glucose

Different concentration of Glucose	O.D (600 nm)	Inhibition Zone Diameter (mm)
0	0.5	2
10	1.7	17
20	1.6	22
30	1.6	22
40	1.6	22

Table -7. Growth and Antimicrobial Activity of Isolates LAB I1 at Different Concentrations of Lactose

Different concentration of lactose	O.D (600 nm)	Inhibition Zone Diameter (mm)
0	0.5	-
10	0.9	-
20	1.3	-
30	1.6	9
40	1.6	14

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ANALYZE OF WEED DENSITY AND WEED BIOMASS IN DIFFERENT RICE ESTABLISHMENT METHOD

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Abstract

Higher cost and demand of labours and shrinking availability of water have forced the farmers to look for an alternative method of rice cultivation as a substitute to existing tranditional method of rice transplanting. Direct dry method of rice transplanting is the alternative method of rice establishment and water saving method but weeds is the most important problem in direct dry method of rice establishment. Against this backdrop, a field study was undertaken during Kuruvai 2021 to evaluated the effect of crop establishment methods and weed management practices on rice and its associated weed flora. The result demonstrated that grain yield obtained under SRI method were significantly superior to other method of rice establishment and it was on par with mechanical method of rice transplanting. Weed density followed the order of direct dry seeded rice cultivation > Drum sowing > conventional transplanting > mechanical transplanting > SRI rice transplanting. With the advancement in age of the crop, sedges dominated in direct method of rice cultivation, broad leaf weeds dominated in transplanting method of rice cultivation. All the herbicides reduce the weed density significantly as compared to weedy check. Maximum density of weeds was observed in weedy check and lowest weed density were observed in PE followed by POE.

Key words: *Weed density, weed dry matter production, grain yield*

Introduction

Rice is the major food crop for most of the population, particularly in Asian countries. In Asia, India is second major rice producer after china, with the contribution of 21.5% to the world rice production. Rice cultivation methods have been changing from time to time in response to technology developments, labour and water availability and increased cost of production and higher cropping intensity. In India, rice is mainly cultivated through conventional method of transplanting, however, alternative to this, direct seeding has been practices successfully in the past two decades with few manipulations, depending on the agro-climatic conditions. Since then, several sowing and crop establishment methods have evolved, such as water seeding, dry direct seeding and wet seeding using dry or pre-germinated seeds and these have offered promise in water scare and labour shortage scenarios. However, in direct seeding practices the emerging seedlings are having very slower initial growth habits (Yadav *et al.*, 2017). Compared to transplanted rice cultivation or the direct dry seeded and wet seeded cultivation the menace due to weeds are higher as the weeds emerges before or simultaneously with the crop emergence and thus

it inturn brings down the final grain yield. Hence, to evade this problem, alternate method of rice establishment need is to be evolved, assessed, and introduced to achieve sustainable crop productivity.

The System Rice Intensification (SRI), a novel method of transplanting rice cultivation, where in the maximum exploitation of the rice genetic potential of the rice cultivars could be attributed by providing a congenial environment for appropriate crop growth to enhance crop productivity and monetary returns. Besides, it also prevents deterioration of soil health altogether with minimal water application and seed rate, etc. (Gayatree Mishra *et al.*, 2018). In India, an economic loss of USD 11 billion has been found to be inflicted by weeds alone in major crops, out of which the share of rice is 21.4% and 13.8% in direct seeded and transplanted rice, respectively. Practice to control weed menace, though manual chemical methods are common. However, manual weeding is a laborious and back breaking process. Chemical weed control, which involves application of different pre- and post-emergence broad spectrum herbicides, had been advocated in rice. Over the years chemical weed control had gained importance in controlling weeds, owing to its advantage over other method of weed control, like ease in such as pretilachlor, bensulfuron-methyl, phyrazosulfuron-ethyl etc and post emergence herbicides such as bispyribac-sodium, penoxsulam, fenoxaprop, aimsulfuron are recommended and usedin direct seeded and transplanted rice in Inida. In this background, a field experiment at experimental farm, faculty of agriculture, annamalai university was conducted to evaluate the response of rice and its associated weed flora to crop establishment methods and weed management practices under clay soil condition.

Materials and methods

A field experiment was conducted at Experimental Farm, Department of Agronomy, Annamalai University during *kuruvai* seasons of 2019-2020 and 2020-2021 to study the effect of different rice establishment methods and weed management practices on establishment percentage and weed population of rice. The study area has mean annual rainfall of about 1500 mm, majority of which was received during North East Monsoon. The climate of the region is characterized by a tropical climate with a hot dry summer (March-May), and extended wet period from November to February. The soil is clayey loam with a pH of 7.3.

In this study the performance of different crop establishment and weed management practices was evaluated. The experiments were conducted in split plot design with three replications. The treatment comprised of five establishment method as main treatments *viz.*, (M_1)- Direct dry seeded rice, (M_2)- Drum seeded rice, (M_3)- SRI transplanting, (M_4)- Machine transplanting, (M_5)- Conventional transplanting and six weed management practices as sub treatments *viz.*, (S_1)- Unweeded control, (S_2)- Two hand weeding on 20 and 40 DAT/ DAS, (S_3)- Pre-emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR(pre-mix) @ 10 kg ha^{-1} on 3 DAT/ 7 DAS + hand weeding on 40 DAT/DAS, (S_4)- Pre-emergence application of pretilachlor 6% + pyrazosulfuron-ethyl 0.15 % GR (pre-mix)@ 10 kg ha^{-1} on 3 DAT/ 7 DAS + hand weeding on 40 DAT/DAS, (S_5)- Pre-emergence application of bensulfuron methyl 0.6% + pretilachlor 6% GR (pre-mix) @ 10 kg ha^{-1} on 3 DAT/ 7 DAS + Post-emergence application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 15 DAT/DAS and (S_6)- Pre-emergence application of pretilachlor 6% + pyrazosulfuron-ethyl 0.15 % GR (pre-mix)@ 10 kg ha^{-1} on 3 DAT/ 7 DAS + Post-emergence application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 15 DAT/DAS. The variety taken for experiment was CO 51 during *kuruvai* 2019-2020. The plot size of experiment was 5 × 4 m. A fertilizer schedule of 120: 40: 40 NPK kg ha^{-1} was adopted as the common practice for the experiment. Full dose of phosphorous and half dose of nitrogen and potassium were applied

basally. The remaining half dose of nitrogen and potassium were applied into two splits during maximum tillering and panicle primordium initiation (PPI) stage. Nitrogen, phosphorous and potassium were supplied through urea, single super phosphate, and muriate of potash respectively. As per the treatment schedule required quantity of herbicides was sprayed and for the treatment S_2 hand weeding was done at 20 and 40 DAT/DAS. The pre-emergence and post-emergence herbicides were sprayed with high volume knapsack sprayer fitted with flood jet nozzle using 500 liters of water ha^{-1}. All the pre-emergence herbicides were sprayed on 3 DAT/ 7 DAS and post-emergence herbicides were sprayed on 15 DAT/DAS respectively.

The field was ploughed to fine tilth and made to puddled condition. Paddy seeds soaked in water for 24 hours were stored in gunny bags for 24 hours. Pre-germinated seeds were filled in seeding drums and sown in the field within the demarked plots. SRI transplanting was done in levelled field under puddled soil condition. For transplanting, a spacing of 25 x 25 cm between inter and intra row and were adopted in both the cropping seasons. Single rice seedlings of 14 days old were used for transplanting. Mechanical transplanting was done in well puddled soil. Mat nursery which was already prepared is used for transplanting with self propelled paddy transplanter, which could plant eight rows in one pass with the spacing of 20 cm × 15 cm during both the years of field experimentation. Under conventional method the row transplanting twenty-five-day old seedlings were transplanted with a spacing of 15 cm × 10 cm in both the years of study. The seedlings were planted in puddled conditions @ two seedlings $hill^{-1}$. Care was taken to fill the gaps on 10^{th} days after transplanting with seedlings of same age. Five sample plots of 1.0 m^2 area in each sub plot treatments in all the replications were peg marked and the established rice seedlings in each sample plots were counted on the day of gap filling operation from which the mean germination were arrived as against the number of seeds/seedlings sown on 15 DAT/DAS to work out the percentage of crop establishment.

The total number of weeds were recorded from the four quadrants of 0.25 m^{-2} area placed at random in each of the net plot area and computed to total weeds m^{-2}. Prior to transplanting the weed species present in the unweeded plots were identified and grouped in to grasses, sedges and broad-leaved weeds. Data on weed population and weed dry matter production showed high variation and hence they were subjected to square root transformation $\sqrt{(x + 0.5)}$ and analyzed.

Result and Discussion

Irrespective of the cropping season and the stages of crop growth, rice establishment methods and weed management practices exerted significant influence on total weed population.

Among the rice establishment methods evaluated, SRI transplanting (M_3) of rice registered lower weed density and lower weed biomass during *Kuruvai* 2021 and were comparable with the mechanical transplanting (M_4) of rice. On other hand, the highest weed density and highest weed biomass during *Kuruvai* 2021 were recorded under direct dry seeding of rice (M_1) crop. Regarding the weed management practices test verified, the lowest total weed density and weed biomass were resulted with the pre-emergence (PE) application of premixed pretilachlor 6% + bensulfuron methyl 0.6% GR @ 10 kg ha^{-1} on 3 DAT/ 7 DAS + post-emergence (PoE) application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 20 DAT/DAS (S_5). However, it was comparable with the PE application of premixed pretilachlor 6% pyrazosulfuron-ethyl 0.15% GR @ 10 kg ha^{-1} on 3 DAT / 7 DAS + PoE application of bispyribac sodium 10% SC @ 200 ml ha^{-1} on 20 DAT/DAS (S_6) at all the stages of crop growth. Regardless the cropping seasons and stages of crop growth the un-weeded control (S_1) resulted with the highest population of total weeds. Although only single seedlings $hill^{-1}$ are being transplanted, the wider inter and intra row spacings of 25 cm would

facilitates maximum germination of weed at initial stage of crop growth. However, the practice of cono weeding adopted under the SRI system on 10th day after transplanting effectively *in situ* incorporated the germinated weeds in soil profile Chakraborty *et al.*, (2017).

Further, the weed germinated at later stages were also periodically incorporated *in situ* with the successive cono weeding operations on 20, 30 and 40 DAT, and it might be the probable reason for lowest population of weeds, nutrient removal, and the dry matter accumulation with this treatment. Similar type inferences were also documented by Ayyadurai and Thiyagarajan (2020). Regarding direct dry seeding of rice (M_1) treatment and the direct seeding of germinated wet seeds with drum seeder (M_2) treatment the beneficial effects of transplanting shock like vigour crop growth resulted through the triggered productivity of growth promoting hormones and the enzymes could not be realised. Moreover, the chance of uneven depth of sowing under these treatments might have also declined the germination and establishment, which is evident from the numerically reduced values of establishment per cent with these treatments in both the cropping seasons. Moreover, the above situations would also facilitates weeds to putforth high competition with the crop to register enhanced population, nutrient uptake and weed dry matter production. The experimental results of Abu Yamah (2002) are also in accordance with the above findings.

Conclusion

From the study, it was concluded that SRI transplanting and mechanical transplanting were registered lowest density of weeds and their biomass. The highest weed density and weed biomass per unit area was recorded in direct dry seeded rice cultivation among the weed management practices sequential application pre-emergence followed by post-emergence herbicidal application reduce the weed density and weed biomass per unit area. Over all the efficacy of PE was better in reducing weed density and weed biomass across the crop establishment methods.

Table 1. Effect of different establishment methods and weed management practices on total weeds density and weed biomass during 2021 cropping season.

Treatment	Total weed density (No. m^{-2}) 60DAT/DAS	Weed biomass (kg ha^{-1}) 60DAT/DAS
Establishment methods		
M_1	10.04 (100.93)	21.23 (450.13)
M_2	9.18 (84.37)	19.31 (372.38)
M_3	7.71 (59.07)	15.36 (190.59)
M_4	8.46 (71.16)	18.20 (33.60)
M_5	8.60 (73.62)	18.32 (335.39)
SEd	0.38	1.01
CD (p=0.05)	0.82	0.48

Weed management practices		
S_1	13.89 (192.64)	18.37 (337.09)
S_2	7.86 (61.35)	8.11 (65.43)
S_3	7.32 (53.16)	7.57 (56.94)
S_4	8.47 (71.27)	8.89 (78.69)
S_5	6.65 (42.35)	6.94 (47.69)
S_6	8.60 (73.62)	7.02 (48.84)
SEd	0.38	0.63
CD (p=0.05)	0.82	0.29

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INNOVATIVENESS OF TURMERIC FARMERS IN PAPPIREDDIPATTI TALUK OF DHARMAPURI DISTRICT IN TAMIL NADU

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Abstract

Turmeric is scientifically called as Curcuma longaand belongs to the family Zingiberaceae. The word 'turmeric' is derived from the latin word "terra merita" that means 'meritorious earth' refers to the color of turmeric. Tamil Nadu ranks second in both production and area under turmeric cultivation among all the states in India. The principal turmeric producing districts in Tamil Nadu are Erode, Dharmapuri, Villupuram, Salem and Namakkal. The present investigation was done in Pappireddipattitaluk of Dharmapuri district. It ranks second in area and production in the state after Erode district. The major turmeric cultivating areas in Dharmapuri are Pappireddipatti, Harur, Nallampalli, Karimangalam, Dharmapuri, Palacode and Pennagaram. Major turmeric producing villages are Venkatasamuthiram, Menasi, Molayanur, A. Pallipatti, Bommidi and Devarajapalayam. So, these six villages were selected for this invesrigation. Sample sizes of 120 turmeric growers were considered sufficient for the study. Majority of the turmeric farmers in this locale had medium level of innovativeness in their farming.

Introduction

India is called as legendary land of spices. Turmeric is scientifically called as *Curcuma longa*and belongs to the family Zingiberaceae. The word 'turmeric' is derived from the latin word "*terra merita"* that means 'meritorious earth' refers to the color of turmeric. Turmeric possesses bright yellow color because of orange yellow pigment called curcumin. India is the 'Spice bowl' of the world. The history of Indian spices dates to the beginning of human civilization. According to the Bureau of Indian Standards, 63 spices including turmeric are grown in India. India is the largest producer of turmeric, producing 100,000 tonnes of cured turmeric annually, of which 94 to 97 per cent is consumed at home. India is the largest producer and consumer and exporter country of turmeric out of total production in the world. Out of yearly production 93 per cent is consumed within the country and remaining 7 per cent is exported. India is a major turmeric supplier to the world with more than 60 per cent share in trade. Turmeric is the largest foreign exchange earner among Indian spices. Tamil Nadu ranks second in both production and area under turmeric cultivation among all the states in India. The principal turmeric producing districts in Tamil Nadu are Erode, Dharmapuri, Villupuram, Salem and Namakkal.Innovativeness was operationalised as the degree to which an individual is relatively earlier in adopting the new ideas. Innovativeness in agriculture means any farmer adopts new idea or technology regarding farming than others in their field.

Locale of Research

The present investigation was done in Pappireddipattitaluk of Dharmapuri district. Dharmapuri is one of the major turmeric producing districts (4,497 ha.) in Tamil Nadu. Dharmapuri

district is situated in the North-Western Agro climatic zone. Minimum temperature prevailing is 16°C and maximum temperature is 38°C. Major horticulture crops cultivated in this district are fruits crops like mango and banana, vegetables like tomato, brinjal, bhendi, onion, chillies and tapioca, spices like turmeric, chillies and tamarind, plantation crops like betel vine, cocoa and areca nut and flowers like tube rose, jasmine, crossandra, marigold, rose and chrysanthemum, medicinal plants like Coleus and Aloe vera and aromatic plants like Palmarosa. Turmeric produced in Dharmapuri is sent throughout the country. It ranks second in area and production in the state after Erode district. The major turmeric cultivating areas in Dharmapuri are Pappireddipatti, Harur, Nallampalli, Karimangalam, Dharmapuri, Palacode and Pennagaram. Pappireddipatti is the major turmeric producing taluk in Dharmapuri district having 1979 hectares. Major turmeric producing villages are Venkatasamuthiram, Menasi, Molayanur, *A. Pallipatti*, Bommidi and Devarajapalayam. So, these six villages were selected for this invesrigation.

Research Methodology

Sample sizes of 120 turmeric growers were considered sufficient for the study. Proportionate random sampling method was adopted to select the 120 turmeric growers from the six selected villages. There are three categories of innovativeness namely as soon as it is brought to my knowledge, after seeing other farmers have done it successfully, I prefer to wait and take my own time followed by the farmers for adopting new technologies. This scoring procedure is followed in this present investigation.

S. No.	Category	Score
1	As soon as it is brought to my knowledge	3
2	After seeing other farmers have done it successfully	2
3	I prefer to wait and take my own time	1

Results and Discussion

Innovativeness in agriculture means any farmer adopts new idea or technology regarding farming than others in their field. The results on distribution of respondents according to their innovativeness are presented below.

S. No.	Category	Number of respondents	Per cent
1	Low	37	30.83
2	Medium	62	51.67
3	High	21	17.50
Total		**120**	**100.00**

It is clear from the Table thatnearly fifty per cent of the respondents had medium (51.67 per cent) level of innovativeness followed by low (30.83 per cent) level of innovativeness. Only 17.50 per cent of the respondents had high level of innovativeness. Medium level of innovativeness may due tothe basic knowledge of education and positive results from the adopted farmers.

Conclusion

Out of the forty-eight villages in Pappireddipattitaluk, six villages were selected based on the maximum area under turmeric cultivation. Therefore, the present investigation was undertaken

to know the innovativeness of the turmeric farmers in pappireddipattitaluk of Dharmapuri district in Tamil Nadu. Majority of the turmeric farmers in this locale had medium level of innovativeness in their farming.

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EFFECT OF FARM YARD MANURE AND BIOSTIMULANTS ON NUTRIENT UPTAKE AND POST HARVEST SOIL NUTRIENT STATUS IN *Jasminum grandiflorum* L. ROOTED CUTTINGS

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Abstract

Nutritional requirement is one of the key factors that governs the growth and development of plants. It becomes an essential need to supplement the crop with organic and artificial sources of nutrients in the form of nitrogen, phosphorus and potassium to the soil. Application of nutrients through foliar sprays demand less quantity of nutrients, with rapid and efficient absorption. In the light of the above, the present study was conducted in the Department of Horticulture, Faculty of Agriculture, Annamalai University, and Annamalainagar. There are ten treatments, replicated thrice by following the principles of randomized block design. The treatments comprised combinations of Panchakavya, Effective Microorganisms, Seaweed extract and humic acid as foliar spray at 15- and 30-days interval along with FYM @ 10 kg/pit and a control. The results of the experiment revealed that the treatment FYM @10 kg/pit along with panchakavya @ 3 % at 15 days interval had recorded the highest nutrient content of 2.45% nitrogen, 0.32% phosphorus and 1.97% potassium in leaves. The maximum post-harvest soil availability of nitrogen 185.81 kg ha^{-1}, phosphorus 8.62 kg ha^{-1} and potassium 317.18 kg ha^{-1} was registered in the treatment which received FYM @ 10 kg/pit plus humic acid @ 0.2 % at 30 days interval.

Introduction

Jasminum grandiflorum L. (Royal or Spanish jasmine, French or Catalonian jasmine) is a large shrub which belongs to the family Oleaceae. The important countries growing Jasmine are Italy, Morocco, North Africa, Belgium, France, Spain and Egypt. In India, it is commercially cultivated in large scale in the states of Tamilnadu, Karnataka, Kerala, West Bengal, Andhra Pradesh, Madhya Pradesh, and Bihar. Nutritional requirement is one of the key factors that governs the growth and development of plants. The natural deposits of nutrients in soils are inadequate to meet the demand of the plants in context of increased pressure for maximizing the productivity. Further, continuous growing of crops depletes the fertility of the soil. Therefore, it becomes an essential need to supplement the crop with organic and artificial sources of nutrients in the form of nitrogen, phosphorus and potassium to the soil. To realize the capacity of plants, it is necessary to determine the rate at which the nutrients are absorbed by the plants and utilized for production purpose. The efficiency of the plants to absorb and assimilate the nutrients depends on several factors and differs with agro climatic conditions in which they are grown. Application of nutrients through foliar sprays demand less quantity of nutrients, with rapid and efficient absorption. Foliar nutrients usually penetrate the cuticle of the leaf and enter the cells. Hence, foliar nutrient is recognized as an important method of fertilization in modern agriculture. Potential sources considered in the present study are Panchakavya, Effective Microorganisms, Seaweed extract and

humic acid. With this background, the present investigation was taken up with a view to elicit and elucidate the information on the above said facts.

Materials and Methods

The present study was conducted in the Department of Horticulture, Faculty of Agriculture, Annamalai University, and Annamalainagar. There are ten treatments, replicated thrice by following the principles of randomized block design. The treatments comprises of T_1- control, T_2- FYM alone @ 10 kg/pit, T_3- FYM + Panchakavya @ 3 % at15 days interval, T_4- FYM + Panchakavya @ 3 % at 30 days interval, T_5- FYM + EM @ 1:100 dilution at 15 days interval, T_6- FYM + EM @ 1:100 dilution at 30 days interval, T_7- FYM + Seaweed Extract @ 3 % at 15 days interval, T_8- FYM + Seaweed Extract @ 3 % at 30 days interval, T_9- FYM + Humic Acid @ 0.2 % at 15 days interval and T_{10}- FYM + Humic Acid @ 0.2 % at 30 days interval. The field was ploughed twice to get a fine tilth. Pits of size 30 cm^3 were formed at a spacing of 2.0 x 1.5 m. Well decomposed FYM was applied uniformly to all the pits @ 10 kg per pit except control. Ninety days old healthy uniform seedlings were transplanted @ one seedling per pit. The organic foliar nutrients were sprayed according to the treatment schedule. The plots were kept free from weeds by periodic hand weeding. The crop was irrigated depending on soil moisture status at an interval of 15 days**.** Pest and diseases were controlled periodically during the crop growth using the recommended plant protection agents.

The sampling of leaves as suggested for ornamental trees and shrubs by Davidson (1960) and cannon *et al.* (1960), was followed. The third pair of leaves from the terminal bud which corresponded to the fully expanded recently mature leaves was collected for analysis. Twenty pairs of leaves were collected from different portions (distributed all around the plant) from each of the experimental plant and pooled together to form the test sample. The samples were collected, dried in a hot air oven at 65 - 70^{O} C for 48 hours. The dried samples were then ground to a very fine powder. These powdered samples were again dried in oven at 60^{O}C for couple of hours and stored in a dessicator till the samples were used for determining the nutrient status.

After 180 DAP, surface soil samples were collected from a depth of 0 - 30 cm from each treatment at two positions, one from centre of the plot and another from in between two plants. The sample collected were mixed and air dried. Then the sample were ground and sieved through 2 mm sieve. These samples were used for estimation of available nitrogen, phosphorus and potassium content of soils. The data obtained were statistically analysed.

Result and Discussion

Leaf Nutrient Content

The results of the experiment are presented in table 1 and 2 and discussed hereunder. Among sixteen essential nutrients, nitrogen, phosphrous and potassium are the major nutrients, which play a vital role in plant physiology and growth. The uptake of nitrogen, phosphorus and potassium were positively influenced by different treatment combinations. In the present investigation, the treatment FYM @10 kg/pit along with panchakavya @ 3 % at 15 days interval had recorded the highest nutrient content of 2.45% nitrogen, 0.32% phosphorus and 1.97% potassium in leaves. This may be due to higher uptake of these elements from the soil due to favourably altered environment brought about by FYM. Besides foliar application of panchakavya might have been absorbed speedily showing higher assimilation of the above major nutrients in the leaf tissue.

Organic manure like FYM when added to the soil, with the action of microorganisms, complex nitrogenous compounds were slowly broken down and it is steady throughout the crop growth (Budhawant, 1994). Further, he revealed that phosphorus uptake increased with the application of organic manures especially FYM, which may be attributed to more solubilisation of native nutrients from the soil due to the action of various organic acids liberated during the decomposition of FYM. The combination of organic manures increased the potassium uptake, which may be described to its role in improving soil properties, in turn leading to better penetration of roots, thereby resulting in more uptake of potassium from native source. The presence of macro (N, P, K and Ca) and micro (Zn, Fe, Cu, Mn) nutrients besides total reducing sugar (glucose) were observed in panchakavya. Chemolithotrops and autotropic nitrifierscammoniters and nitrifiers present in panchakavya which colonize in the leaves increase the ammonia uptake and enhance the total N supply as reported by Papen *et al*. (2002).

Post-Harvest Soil Fertility Status

The result of the present investigation clearly showed that the available N, P and K content of the soil was positively increased by the application of FYM along with bio stimulants. The maximumpost-harvest soil availability of nitrogen 185.81 kg ha^{-1}, phosphorus 8.62kg ha^{-1}and potassium317.18kg ha^{-1}was registered in the treatment which received FYM @ 10 kg/pit plus humic acid @ 0.2 % at 30 days interval. The favourable response might also be ascribed to the tendency of humic acid to extract more phosphorus from nature source leading to increased availability of phosphorus in soil (Hengi, 1989), further Lee and Bartlett (1976) and Mary *et al*. (2002) also found that humic acid form a protective film on the absorbing surface of soil, thereby decreasing the possibility of P retention and increase in solubility. The reason might be due to the slow release of nutrient from the FYM, resulting in the lesser loss and further availability of nutrient can also be achieved in due course of time due to degradation. (Ganesan, 2011). The increase in the available phosphorus content of soil may be attributed to organic acid produced during decomposition of FYM, preventing the conversion of soluble form of phosphorus to insoluble form of phosphorus and enhanced the solubilization of native phosphorus in the soil (Prasanna and Kumar, 2001).

From the present investigation, it may be concluded that application of FYM @ 10 kg/pit plus panchakavya @ 3 % at 15 days interval was found to have beneficial effect on nutrient uptake and soil fertility management in *J. Grandiflorum*.

Table 1. Response of *Jasminum grandiflorum* L. rooted cuttings to various organic inputs on leaf nutrient content.

Treatments		Leaf Nutrient content (%)		
		N	N	N
T_1	Control	0.82	0.13	0.76
T_2	FYM alone @ 10 kg/pit	1.05	0.17	0.91
T_3	FYM+ Panchakavya @ 3 % at15 days interval	2.45	0.32	1.97
T_4	FYM+ Panchakavya @ 3 % at 30 days interval	1.84	0.25	1.42
T_5	FYM+ EM @ 1:100 dilution at 15 days interval	2.30	0.30	1.86
T_6	FYM+ EM @ 1:100 dilution at 30 days interval	1.69	0.23	1.27
T_7	FYM+ Seaweed Extract @ 3 % at 15 days interval	2.19	0.29	1.71
T_8	FYM+ Seaweed Extract @ 3 % at 30 days interval	1.38	0.19	1.02
T_9	FYM+ Humic Acid @ 0.2 % at 15 days interval	2.04	0.27	1.62
T_{10}	FYM+ Humic Acid @ 0.2 % at 30 days interval	1.50	0.20	1.10
	SEd	0.052	0.005	0.020
	CD (p=0.05)	0.109	0.010	0.042

Table 2. Response of *Jasminum grandiflorum* L. rooted cuttings to various organic inputs on post harvest soil fertility status

Treatments		Leaf Nutrient content (%)		
		N	N	N
T_1	Control	174.33	6.13	308.12
T_2	FYM alone @ 10 kg/pit	175.10	6.52	309.80
T_3	FYM+ Panchakavya @ 3 % at15 days interval	177.22	6.86	312.64
T_4	FYM+ Panchakavya @ 3 % at 30 days interval	182.50	7.25	315.00
T_5	FYM+ EM @ 1:100 dilution at 15 days interval	175.30	6.72	310.22
T_6	FYM+ EM @ 1:100 dilution at 30 days interval	180.20	7.11	314.21
T_7	FYM+ Seaweed Extract @ 3 % at 15 days interval	184.20	8.33	310.20
T_8	FYM+ Seaweed Extract @ 3 % at 30 days interval	183.82	7.81	315.36
T_9	FYM+ Humic Acid @ 0.2 % at 15 days interval	178.50	7.00	313.25
T_{10}	FYM+ Humic Acid @ 0.2 % at 30 days interval	185.81	8.62	317.18
	SEd	0.132	0.151	0.230
	CD (p=0.05)	0.279	0.317	0.483

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EFFECT OF STAKING AND INTERCROPPING ON PRODUCTIVITY OF GREATER YAM (*Dioscorea alata*) IN YAM BASED CROPPING SYSTEM

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Abstract

Root and tuber crops are one of the important climate resilient food crops. Dioscorea species (yams) are most valuable food security crops that sustain many livelihoods in the tropics and subtropics. The high cost of producing greater yam discourages the farmers from increasing areas of this crop. The high production cost is mainly arising from the planting material cost (seed tuber), staking operation and high labour requirement. The main objective of the study was to assess the effect of staking and intercropping on productivity and net economic return of greater yam in yam based cropping system. The greater yam was raised as sole crop (with and without staking) and intercropped with maize, cumbu and pigeon pea at 1:3 ratio. The greater yam recorded maximum yield in sole crop with staking individual plants (38.25 t/ha) eventually tap more light to give a higher yield than sole, unstaked yam (29.49 t/ha). Based on the highest Land Equivalent Ratio (1.68), Income Equivalent Ration (1.79), Yam Equivalent Yield (38.59 t/ha) and Bnefit cost ratio (3.36), intercropping unstaked greater yam with maize in 1:3 ratio was recorded as the best cropping system which reduces the cost of staking and labour requirement.

***Key words**: Greater Yam- Cropping System- Inter Cropping- Staking- LER- IER- BCR- Yield.*

Introduction

Yam is the common name for some plant species that form edible tubers in the genus Dioscorea (family Dioscoreaceae). These are perennial herbaceous vines mainly cultivated for the consumption of their starchy tubers. Consumer demand for the yam is generally very high in the tropical countries and yam cultivation is very profitable despite the high production costs. The greater yam, *Dioscorea alata*, also known as water yam, purple yam and winged yam was initially cultivated in South East Asia and later has the largest distribution world wide of any cultivated yam being grown in Asia, the Pacific Islands, Africa, and West Indies. Yam (Dioscorea spp.) is a tropical crop grown in 47 countries in tropical and sub-tropical regions in an area of 5 million hectares (Acquaah, 2005; IITA, 2009).

In India, greater yam is cultivated in the states of Kerala, Andhra Pradesh, West Bengal, Bihar, North Eastern states, Odisha, Tamil Nadu, Uttar Pradesh, Maharashtra, and Gujarat (Chadha, 2002). The yam tubers are rich source of carbohydrates, proteins, and essential amino acids. Normally yam tubers are consumed as boiled, fried, or baked vegetables. They are also useful for making flour, flakes, and chips. Since greater yam is a climber, it responds well to staking or any kind of artificial support. The use of stakes is laborious and consumes about 20% of additional labour and major cost of yam production (Wholey and Haynes, 1971; Koli, 1973; Asante, 1996). In commercial yam cultivation staking is a costly practice next to seed material. If greater yam is

planted without staking, the crop will be destroyed by the anthracnose (*Colletotrichum gloeosporioides* Penz) disease (Chadha, 2002). Staking of yam vines exposes the leaves to sunlight resulting in better photosynthesis. Yams can be staked with different supports such as bamboo and casuarina poles. Non-staking resulted in 32.5% yield reduction as compared to vertical staking option (Ennin *et al*., 2014). The objective of the present study was to find out suitable alternative for live staking as well as to reduce the cost of cultivation and increasing the revenue.

Materials and Methods

Description of Experimental Sites

The study was conducted in the Department of Vegetable Crops, Horticultural College and Research Institute, Coimbatore, Tamil Nadu during 2015 and 2016 cropping seasons. The experimental site is characterized with clay loamy soil texture and rich in organic matter content. Coimbatore is situated at an elevation of 426 M (longitude: 77°E and latitude: 11oN) and receives on an average 650- 700 mm rainfall annually. The average temperature at the experimental site ranges from 25^{o}C-38^{o}C. The preplant and post harvest soil nutrient status was presented in Table 1

Experimental Design and Cultural Practices

The experiment was established in early June of 2016 and 2017 and harvested in late January of 2017 and 2018, respectively, to assess the effect of staking and intercropping systems on growth atributes, yield and economics of greater yam. A total of eight treatments including three intercrop systems viz., T_1- Greater yam sole crop non-staking (90cm x 90 cm); T_2-Pigeon pea sole crop non-staking (60 cm x 30 cm); T_3- Maize sole crop non-staking (60 cm x 30 cm); T_4- Jowar sole crop non-staking (60 cm x 30 cm); T_5- Greater yam + Pigeon pea (1:2) additive; T_6- Greater yam + Maize (1:2) additive; T_7-Greater yam + Jowar (1:2) additive; T_7- Greater yam sole (90cm x 90 cm) staking individual plants were used. In intercropping, pigeon pea, Maize and Jowar to be grown in intra rows of greater yam. Thus, the intercrops spacing will be 90 cmx 30 cm and trailing can be done on the respective intercrop.

Each plot measured 9 x 5.4 m (48.6 m2) and contained 60 plants. Setts each weighing 250 g were used as planting materials. The setts were planted into holes 15 cm deep spaced 90cm x 90cm in a complete randomized block design. Staking was done prior to sprouting of planted setts by inserting pointed stake supports into the soil about 20 cm away from planted holes or spots.

Data Collection

Mean productivity of greater yam tuber per unit area, intercrop yield per unit area and competition indices among the intercrops and main crop were collected during the experimental period. A total of fourteen characters of various growth and yield traits were recorded. Data were subjected to analysis of variance (ANOVA) using the AGRES statistical programme. The land use efficiency and the competition indices were calculated in the following equations:

Land equivalent ratio (LER)

Land Equivalent Ratio is a concept in agriculture used to assess the advantage of mixed crop stand. The LER indicates the efficiency of intercropping compared with monocropping for using the resources of the environment (Mead and Willey, 1980). It is the sum of fractions of inter crop yield divided by sole crop yield. When the Land Equivalent Ratio is more than one, the intercropping favors the growth and yield of the species. The LER was calculated as (Willey and Osiru, 1972).

$$LER = (Y_{AB}/Y_{AA}) + (Y_{BA}/Y_{BB})$$

Where; Y_{AB}= Yield of crop A when intercropped with crop B

Y_{BA}= Yield of crop B when intercropped with crop A

Y_{AA}= Yield from sole planted crop A

Y_{BB}= Yield from sole planted crop B

Income equivalent ratio (IER)

IER is a similar concept like LER, except that yield is measured in terms of net income, rather than productivity in terms of plant product. To calculate the Income Equivalent Ratio market price of produces or gross income (GI) obtained from intercropping in one hectare land will be used. The IER for a particular intercropping system may vary in different years as price of produce fluctuates. It can be calculated as per the formula developed by Ghaffarzadeh, 1979

$$IER = \frac{\text{GI/ha of intercropped crop A}}{\text{GI/ha of sole cropped crop A}} + \frac{\text{GI/ha of intercropped crop B}}{\text{GI/ha of sole cropped crop B}}$$

Equivalent yield (EY)

Yields of both main and inter crops were taken from the whole plot. Greater yam equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula developed by Bandyopadhyay (1984) as given below:

$$GYeq = Yigy + \frac{Yii \times Pi}{Pgy}$$

Where, GYeq = Greater yam equivalent yield

Yigy = Yield of maincrop greater yam, Yii =Yield of intercrop

Pgy = Price of greater yam, Pi = Price of intercrop

Results and discussion

Staking contributes to increase growth and development of greater yam (Table 2). Greater Yam produced under staking condition out-grows and out-yields those in the non-staked system (Norman *et al*., 2015). Ennin *et al*., (2014) reported that vertical staking option had the highest fresh leaf, dry leaf and vine weight which translated into highest tuber yield and numbers.

Productivity of intercroping system

Intercropping greater yam with differenct crop showed variable amount of yield difference (Table-6). Fresh tuber yield of greater yam was significantly higher in stake plots (38.25 ton/ha) than the non-stake plots (29.49 t/ha). The highest greater yam mean tuber yield was obtained at 1 greater yam: 2 maize intercropping system (36.79 t/ha).

Productivity of greater Yam under staked system was significantly higher than those from non-staked control plots (Tsado, 2012 and Norman *et al*., 2015). Similar results were observed by Islam *et al*., (2014) in maize: sweetpotato intercropping system. A yield increase of 50 to 60% was observed by Thomos *et al*., (2007) in staked crop compared to non-staked crop in Cameroon. Norman *et al*., (2015) observed 37 - 45% more yield in stake plots compared to non-stake plots.

Another study on staking options using a promising non-staked yam line TDR95/19177 showed that non-staked yam resulted in a high (32.5%) yield reduction (Ennin *et al*., 2014).

Land equivalent ratio (LER)

Total LER were influenced by different intercropping systems (Table 6) which varied form1.68 in 1 greater yam: 2 maize, 1.63 in1 greater yam: 2 jowarand1.53 in1 greater yam: 2 pigeon pea intercropping arrangements, which shows an advantage from those intercropping systems over pure stands in terms of the use of environmental resources for plant growth (Mead and Willey, 1980). Emuh *et al*. (2012) reported that, Within the 3 crops association studied, tall staked yam had higher LER than medium or short staked yam. The highest IER was also recorded (Table 6) in 1 greater yam: 2 maize intercropping arrangement (1.79), which shows an advantage from other intercropping arrangements and pure stands.

The efficiency of intercrop based on the equivalent yield and benefit cost ratio

Total productivity in terms of equivalent yields and economic study of greater yam based intercropping presented in table 8. Among intercropping systems, the highest greater yam equivalent yield (38.59 t ha-1) was recorded in 1 greater yam: 2 maize combination which was much higher than other combinations. This is in line with the findings of study conducted by Uddin *et al*. (2006). The highest benefit cost ratio (3.6) was also recorded in1 greater yam: 2 maize combination indicating profitable combination of maize greater yam intercropping systems. The results are consistent with those obtained by Dorosh (1988) and Norman et al., (2015). In this intercropping system maize not only provided additional yield but also acted as a live stake for the greater yam vines. Similar results were observed in the findings of the studies conducted by Antaryami Lenka et al., (2013), Begum et al. (2010) and Islam et al. (2013).

Conclusion

The results of the current study revealed that staking is beneficial in greater yam production contributing an average of 22.9% more fresh tuber yields than crop without staking (trailing on the ground). Leaves of staked crop have greater opportunity to intercept sunlight effectively with proper aeration, which promote photosynthetic activity results in heavier tuber formation and ultimately high yield. Staking also reduces the soil born infection and spread of diseases from one plant to another. Even though Staking is expensive, laborious and difficult to mechanize, Greater yam 1 row + 2 rows maize combination could be suitable for increasing productivity and profitability. This implies that intercropping is indeed a sustainable farming practice especially in crop like greater yam.

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FORAGING ACTIVITY OF INDIAN HONEYBEE, APIS CERANA INDICA (HYMENOPTERA: APIDAE) DURING HONEY FLOW SEASON AT ANNAMALAI UNIVERSITY, CHIDAMBARAM, TAMIL NADU

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Abstract

Foraging activityof Indian honey bee Apis cerana indica was evaluated during honey flow season at Annamalai University during 2021-2022. The results revealed that the bees foraging activity (outgoing bees) was recorded highest during 10.00-11.00 h and lowest at 06.00-07.00 h during the month of January and April. In February and March, highest foraging activity recorded during 11.00-12.00 and lowest recorded at 06.00-07.00 h. The nectar gatherers activity recorded highest at 12.00-13.00 h during the month of January, February, and April. In March, foraging activity of honeybees was highest during 11.00-12.00 h. The pollen gathering activity was recorded highest at 08.00-09.00 h during the month of January. In February and April, peak pollen foraging activity was recorded during 10.00-11.00 h respectively.

Keywords: *Honey bee, Apis cerana indica, honey flow season, foraging activity, outgoing bees, Pollen, and Nectar foraging.*

Introduction

Beekeeping is an art and mesmerizing science. In India, beekeeping is an important component of agriculture and rural development programmes. Beekeeping can be done for both their pollination services and their cherished products such as honey, beeswax, propolis, bee venom, royal jelly and pollen (Tej*et al*., 2017). Honey bees need pollen and nectar from plants as the primary ingredients in their diet, and collect in fascinating waysknown as foraging (Sharma, 1970). Foraging activity decides the efficiency of bee survival and it directly reflects on the honey production during honey flow season (Hemalatha*et al*., 2018). Several reports were available for foraging activity fluctuations in *Apis mellifera* with different seasons and such studies were found scarce on *A. cerana indica*in the coastal region of Chidambaramin Tamil Nadu and hence the present work was focused on foraging activity of *A. cerana indica* during honey flow season.

Materials and Methods

The experiment was conducted during 2021 to 2022, in apiary unit of Annamalai University, Chidambaram. Foraging activity of bees was determined by counting the number of worker bees going out and returning to the hive with and without the pollen loads and was counted for five minutes by using hand tally counter and stop watch. Bees returning without pollen loads were considered as nectar gatherers. Weekly observations were recorded at hourly intervals starting from 06.00 a.m. to 06.00 p.m. for five minutes during honey flow season (Hemalatha*et al*., 2018). The mean values were square root transformed and compared by Least Significant Difference (LSD) at 5 % probability to assess the peak foraging activity during different time interval (Gomez and Gomez, 1984).

Results and Discussion

The results of the experiment were given in Table 1 revealed that the bees foraging activity (outgoing bees) was recorded highest during 10.00-11.00 h followed by 09.00-10.00 h and lowest

foraging activity at 06.00-07.00 h during the month of January and April. In February and March, highest foraging activity recorded during 11.00-12.00 h followed by 09.00-10.00 h and lowest foraging activity recorded at 06.00-07.00 h, respectively. Similar result was also observed by Mattu and Verma (1985) where the peak periodof flight was at 11.00 h (18.27 %). Hemalatha*et al.* (2018) also reported that foraging activity was maximum during 3rd, 4th and 5th standard weeks by registering 10.30 per cent,9.91 per cent and 9.26 per cent activity respectively.

The nectar gatherers activity of Indian honey bees was recorded highest at 12.00-13.00 h followed by 11.00-12.00 h during the month of January, February, and April. In March, highest foraging activity recorded during 11.00-12.00 h followed by 12.00-13.00 h (Table 2). The results are in accordance with the reports of Mattu and Verma (1985) where the peak nectar foraging activity was observed during 14.00 h in the month of February. During March and April, peak nectar foraging activity was observed during 08.00 h and 13.00 h.

The pollen gatherers were recorded highest at 08.00-09.00 h during the month of January. In February and April, peak foraging activity was recorded during 10.00-11.00 h followed by 11.00-12.00 h respectively (Table 3). The present findings are in conformity with the results of Mattu and Verma (1985) where the maximum pollen collection activity was observed at 10.00 and 12.00 h during February. During March and April, peak pollen foraging activity was at 09.00 h.

Table 1. Foraging activity of A. cerana indicaduring honey flow season (No. of bees venturing out from hive/ 5 min/ h)

Time (h)	January				February				March				April			
	$^{\$}$SMW 1#	SMW 2#	SMW 3#	SMW 4#	SMW 6#	SMW 7#	SMW 8#	SMW 9#	SMW 10#	SMW 11#	SMW 12 #	SMW 13 #	SMW 14#	SMW 15#	SMW 16 #	SMW 17 #
06.00-07.00	22.15 (4.80)^{f}	13.09 (3.74)^{f}	31.21 (5.67)^{f}	29.19 (5.48)^{e}	47.31 (6.94)^{fg}	34.23 (5.93)^{f}	38.25 (6.26)^{g}	29.19 (5.48)^{f}	35.23 (6.01)^{i}	29.19 (5.48)^{g}	41.27 (6.49)^{g}	38.25 (6.25)^{h}	32.21 (5.75)^{fg}	46.46 (6.87)^{fg}	27.27 (5.31)^{f}	23.23 (4.96)^{d}
07.00-08.00	45.30 (6.79)^{de}	56.37 (7.56)^{bc}	42.28 (6.57)^{ef}	68.45 (8.32)^{c}	81.54 (9.07)^{cd}	77.51 (8.85)^{c}	60.40 (7.82)^{ef}	53.35 (7.36)^{e}	43.28 (6.64)^{hi}	57.38 (7.62)^{f}	75.5 (8.73)^{def}	62.41 (7.95)^{ef}	46.30 (6.86)^{e}	58.38 (7.69)^{ef}	39.26 (6.33)^{de}	48.32 (7.01)^{c}
08.00-09.00	73.49^{c} (8.62)	140.93 (11.89)^{a}	96.64 (9.87)^{b}	73.49 (8.62)^{c}	94.63 (9.76)^{bc}	103.69 (10.21)^{b}	93.62 (9.71)^{cd}	86.57 (9.34)^{d}	79.52 (8.96)^{def}	90.60 (9.55)^{cd}	88.58 (9.45)^{de}	83.55 (9.18)^{d}	127.84 (11.33)^{b}	107.71 (10.41)^{b}	78.52 (8.90)^{c}	67.44 (8.26)^{b}
09.00-10.00	94.63 (9.76)^{b}	162.07	109.73	98.65 (9.97)^{b}	89.59 (9.50)^{bcd}	119.79 (10.97)^{b}	124.83 (11.19)^{b}	101.67 (10.11)^{cd}	94.62 (9.76)^{cde}	95.63 (9.81)^{c}	114.76	107.71	99.66 (10.01)^{c}	103.68 (10.21)^{bc}	139.92	93.62 (9.71)^{a}

		(12.75)^{a}	(10.51)^{b}								(10.74)^{c}	(10.41)^{c}			(11.95)^{a}	
10.00-11.00	173.15 (13.17)^{a}	158.05 (12.59)^{a}	144.96 (12.06)^{a}	121.80 (11.06)^{a}	156.03 (12.51)^{a}	174.15 (13.21)^{a}	164.09 (12.82)^{a}	195.29 (13.98)^{a}	126.84 (11.28)^{ab}	184.22 (13.58)^{ab}	176.16 (13.28)^{b}	187.24 (13.69)^{b}	133.88 (11.59)^{b}	168.11 (12.98)^{a}	100.66 (10.06)^{b}	87.58 (9.39)^{a}
11.00-12.00	154.02 (12.43)^{a}	67.45 (8.26)^{b}	115.77 (10.79)^{b}	103.69 (10.21)^{ab}	149.99 (12.27)^{a}	203.35 (14.27)^{a}	186.23 (13.66)^{a}	218.44 (14.79)^{a}	147.98 (12.18)^{a}	212.40 (14.58)^{a}	209.38 (14.48)^{a}	224.48 (14.99)^{a}	166.10 (12.90)^{a}	171.13 (12.09)^{a}	154.02 (12.43)^{a}	79.52 (8.96)^{ab}
12.00-13.00	44.85 (6.76)^{de}	52.34 (7.29)^{c}	72.48 (8.56)^{c}	62.41 (7.95)^{c}	107.71 (10.41)^{b}	127.84 (11.33)^{b}	116.77 (10.83)^{bc}	189.25 (13.77)^{a}	108.72 (10.45)^{bc}	163.08 (12.78)^{b}	156.03 (12.51)^{b}	173.14 (13.17)^{b}	78.52 (8.90)^{d}	84.56 (9.23)^{cd}	72.48 (8.55)^{c}	51.34 (7.22)^{c}
13.00-14.00	36.24 (6.09)^{e}	43.29 (6.64)^{cd}	56.37 (7.56)^{d}	68.45 (8.32)^{c}	52.35 (7.29)^{fg}	72.48 (8.56)^{cd}	84.56 (9.23)^{d}	153.01 (12.39)^{b}	71.47 (8.50)^{fg}	84.56 (9.23)^{cde}	96.64 (9.86)^{cd}	81.54 (9.09)^{de}	67.44 (8.26)^{d}	82.54 (9.12)^{cd}	74.49 (8.67)^{c}	44.29 (6.72)^{c}
14.00-15.00	22.05 (4.80)^{f}	27.18 (5.30)^{e}	32.21 (5.75)^{ef}	47.31 (6.94)^{d}	39.26 (6.33)^{g}	43.29 (6.64)^{ef}	51.34 (7.22)^{fg}	118.78 (10.92)^{c}	76.50 (8.79)^{ef}	69.46 (8.38)^{ef}	73.48 (8.61)^{ef}	70.46 (8.44)^{def}	42.28 (6.56)^{ef}	88.58 (9.45)^{bcd}	67.44 (8.26)^{c}	51.34 (7.22)^{c}
15.00-16.00	57.38 (7.63)^{d}	31.21 (5.67)^{e}	57.38 (7.63)^{cd}	64.43 (8.08)^{c}	73.49 (8.61)^{de}	56.37 (7.56)^{de}	77.51 (8.84)^{de}	95.63 (9.81)^{cd}	96.64 (9.86)^{cd}	73.48 (8.61)^{def}	84.56 (9.23)^{de}	87.58 (9.39)^{cd}	70.46 (8.44)^{d}	98.65 (9.96)^{bc}	84.56 (9.23)^{bc}	65.43 (8.13)^{b}
16.00-17.00	42.28 (6.57)^{e}	26.17 (5.20)^{e}	44.29 (6.72)^{de}	39.26 (6.33)^{de}	61.41 (7.89)^{ef}	59.39 (7.76)^{cde}	63.42 (8.01)^{ef}	53.35 (7.36)^{e}	57.38 (7.62)^{gh}	61.40 (7.88)^{f}	59.39 (7.75)^{f}	54.36 (7.42)^{fg}	68.45 (8.32)^{d}	76.50 (8.70)^{de}	51.34 (7.22)^{d}	42.28 (6.56)^{c}
17.00-18.00	35.23 (6.01)^{e}	33.22 (5.84)^{de}	39.26 (6.33)^{ef}	17.11 (4.25)^{f}	38.25 (6.26)^{g}	47.31 (6.94)^{ef}	52.34 (7.29)^{fg}	32.21 (5.75)^{f}	40.26 (6.41)^{i}	38.25 (6.25)^{g}	36.24 (6.09)^{g}	42.28 (6.56)^{gh}	25.16 (5.10)^{g}	41.27 (6.49)^{g}	37.24 (6.17)^{ef}	28.18 (5.39)^{d}
SE(d)	**0.157**	**0.178**	**0.125**	**0.115**	**0.122**	**0.153**	**0.133**	**0.184**	**0.113**	**0.163**	**0.149**	**0.163**	**0.140**	**0.120**	**0.127**	**0.088**

C. D. (P=0.05)	**0.329***	**0.371***	**0.260***	**0.240***	**0.254***	**0.320***	**0.279***	**0.384***	**0.235***	**0.341***	**0.312***	**0.341***	**0.292***	**0.251***	**0.265***	**0.185***

 # - Each value is a mean of three observations; *- significance at P = 0.05; Figures in parenthesis are square root transformed values; In a column, means followed by same letter(s) are on par by LSD (p= 0.05);$- SMW- Standard Mean Week

Table 2. Foraging activity of *A. cerana indica* during honey flow season (No of bees venturing into the hive with nectar load /5 min/ h)

Time (h)	**January**				**February**				**March**				**April**			
	$SMW 1#	**SMW 2#**	**SMW 3#**	**SMW 4#**	**SMW 6#**	**SMW 7#**	**SMW 8#**	**SMW 9#**	**SMW 10#**	**SMW 11#**	**SMW 12#**	**SMW 13#**	**SMW 14#**	**SMW 15#**	**SMW 16#**	**SMW 17#**
06.00-07.00	6.97 (2.82)^{k}	15.94 (4.10)^{k}	21.92 (3.59)^{i}	18.93 (4.45)^{i}	30.79 (5.62)^{i}	15.89 (4.10)^{j}	24.83 (5.07)^{j}	20.86 (4.66)^{k}	23.07 (4.90)^{j}	18.79 (4.44)^{k}	26.08 (5.19)^{g}	20.87 (4.67)^{l}	18.12 (4.36)^{h}	20.93 (4.67)^{j}	16.10 (4.12)^{g}	19.93 (4.56)^{g}
07.00-08.00	22.92 (4.88)^{j}	20.93 (4.67)^{j}	11.96 (7.32)^{j}	47.84 (6.97)^{ef}	38.74^{h} (6.29)	17.88 (4.33)^{j}	41.72 (6.52)^{i}	55.62 (7.511)^{i}	21.07 (4.69)^{j}	29.23 (5.49)^{i}	33.11 (5.83)^{f}	42.80 (6.61)^{h}	24.16 (5.00)^{g}	26.91 (5.27)^{i}	18.35 (4.39)^{g}	14.95 (3.98)^{i}
08.00-09.00	40.86 (6.45)^{h}	32.89 (5.81)^{i}	52.82 (8.39)^{f}	43.85 (6.68)^{g}	57.61 (7.64)^{f}	48.67 (7.03)^{f}	52.64 (7.31)^{g}	72.51 (8.55)^{h}	46.15 (6.85)^{h}	67.85 (8.29)^{f}	58.19 (7.68)^{d}	54.28 (7.43)^{f}	38.25 (6.25)^{f}	41.86 (6.53)^{g}	22.14 (4.80)^{f}	27.90 (5.36)^{f}
09.00-10.00	48.83 (7.04)^{g}	71.76 (8.51)^{e}	69.76 (8.80)^{d}	63.14 (7.99)^{c}	70.52 (8.44)^{e}	68.54 (8.32)^{e}	86.42 (9.33)^{d}	78.47 (8.89)^{g}	93.31 (9.69)^{d}	64.72 (8.10)^{g}	73.24 (8.60)^{c}	70.98 (8.48)^{e}	51.34 (7.22)^{e}	63.78 (8.03)^{e}	46.30 (6.86)^{d}	50.83 (7.18)^{ab}
10.00-11.00	83.72 (9.18)^{e}	101.66 (10.11)^{c}	76.74 (10.25)^{c}	73.75 (8.62)^{b}	77.48 (8.84)^{d}	81.45 (9.06)^{d}	109.26 (10.48)^{a}	126.15 (11.25)^{c}	107.35 (10.39)^{c}	89.77 (9.52)^{d}	98.32 (9.95)^{b}	105.43 (10.31)^{c}	77.51 (8.84)^{c}	68.77 (8.33)^{d}	71.47 (8.49)^{c}	47.84 (6.97)^{c}
11.00-12.00	116.61 (10.82)^{b}	110.63 (10.54)^{b}	104.65 (9.96)^{a}	80.73 (9.02)^{a}	99.33 (9.99)^{b}	106.28 (10.33)^{b}	97.34 (9.89)^{b}	145.02 (12.06)^{a}	115.38 (10.77)^{b}	143.01 (11.99)^{a}	126.42 (11.27)^{a}	138.84 (11.81)^{a}	82.54 (9.12)^{c}	102.65 (10.16)^{b}	117.78 (10.87)^{a}	52.82 (7.32)^{a}
12.00-13.00	138.53	118.60	98.67	75.74	112.24	140.06	110.26	115.22	129.43	128.40	94.31	119.00	112.74	132.55	89.59	48.83

	(11.78)^{a}	(10.91)^{a}	(7.58)^{b}	(8.74)^{b}	(10.62)^{a}	(11.85)^{a}	(10.52)^{a}	(10.76)^{d}	(11.40)^{a}	(11.37)^{b}	(9.74)^{b}	(10.94)^{b}	(10.64)^{a}	(11.53)^{a}	(9.49)^{b}	(7.04)^{bc}
13.00-14.00	107.64 (10.40)^{c}	82.72 (9.13)^{d}	56.81 (7.39)^{e}	46.84 (6.90)^{f}	84.43 (9.22)^{c}	88.40 (9.43)^{c}	91.38 (9.594)^{c}	137.08 (11.72)^{b}	84.28 (9.22)^{e}	97.08 (9.89)^{c}	76.25 (8.77)^{c}	85.60 (9.30)^{d}	98.65 (9.96)^{b}	80.73 (9.02)^{c}	73.48 (8.61)^{c}	42.85 (6.61)^{d}
14.00-15.00	92.69 (9.66)^{d}	49.11 (7.06)^{g}	53.82 (6.97)^{ef}	50.83 (7.18)^{d}	45.69 (6.82)^{g}	41.72 (6.52)^{g}	85.42 (9.27)^{d}	105.29 (10.29)^{e}	69.23 (8.36)^{f}	82.47 (9.13)^{e}	60.20 (7.81)^{d}	45.93 (6.84)^{g}	66.44 (8.19)^{d}	56.81 (7.58)^{f}	47.31 (6.93)^{d}	50.83 (7.18)^{ab}
15.00-16.00	81.72 (9.07)^{e}	44.85 (6.75)^{h}	47.84 (6.47)^{g}	49.45 (7.09)^{de}	37.74 (6.21)^{h}	22.84 (4.87)^{i}	62.58 (7.95)^{e}	77.80 (8.86)^{g}	71.23 (8.48)^{f}	40.71 (6.45)^{h}	48.16 (7.00)^{e}	32.36 (5.77)^{i}	48.32 (7.00)^{e}	60.79 (7.84)^{ef}	50.33 (7.15)^{d}	32.16 (5.74)^{e}
16.00-17.00	55.81 (7.52)^{f}	62.79 (7.97)^{f}	41.05 (6.22)^{h}	62.79 (7.97)^{c}	47.68 (6.96)^{g}	35.76 (6.05)^{j}	58.60 (7.70)^{f}	86.42 (9.33)^{f}	63.21 (8.00)^{g}	42.80 (6.61)^{h}	35.11 (6.00)^{f}	22.96 (4.89)^{k}	39.26 (6.33)^{f}	31.89 (5.72)^{h}	39.54 (6.35)^{e}	27.90 (5.36)^{f}
17.00-18.00	28.90 (5.45)^{i}	42.85 (6.61)^{h}	37.87 (0.26)^{h}	26.91 (5.27)^{h}	26.82 (5.26)^{j}	33.77 (5.88)^{h}	48.24 (7.00)^{h}	50.66 (7.174)^{j}	39.13 (6.32)^{i}	27.14 (5.30)^{j}	33.11 (5.83)^{f}	26.09 (5.20)^{j}	19.12 (4.47)^{h}	21.92 (4.77)^{j}	17.35 (4.26)^{g}	17.94 (4.34)^{h}
SE(d)	**0.177**	**0.147**	**0.128**	**0.091**	**0.111**	**0.157**	**0.114**	**0.136**	**0.124**	**0.080**	**0.107**	**0.081**	**0.140**	**0.141**	**0.145**	**0.081**
C.D. (P=0.05)	**0.369***	**0.307***	**0.267***	**0.190***	**0.231***	**0.329***	**0.239***	**0.284***	**0.259***	**0.167***	**0.224***	**0.168***	**0.292***	**0.293***	**0.303***	**0.170***

- Each value is a mean of three observations; *- significance at P = 0.05; Figures in parenthesis are square root transformed values; In a column, means followed by same letter(s) are on par by LSD (p= 0.05);$- SMW- Standard Mean Week

Table 3. Foraging activity of *A. cerana indica* during honey flow season (No. of bees entering into the hive with pollen load /5 min/ h)

Time (h)	**January**				**February**				**March**				**April**			
	$SMW 1#	**SMW 2#**	**SMW 3#**	**SMW 4#**	**SMW 6#**	**SMW 7#**	**SMW 8#**	**SMW 9#**	**SMW 10#**	**SMW 11 #**	**SMW 12 #**	**SMW 13 #**	**SMW 14#**	**SMW 15#**	**SMW 16#**	**SMW 17#**
06.00-07.00	12.08 (3.61)^{h}	17.11 (4.25)^{g}	15.25 (4.02)^{i}	20.9 (4.67)^{d}	19.06 (4.47)^{d}	16.05 (4.12)^{e}	11.25 (3.49)^{g}	5.01 (2.44)^{j}	11.96 (3.59)^{g}	6.97 (2.82)^{j}	14.95 (3.98)^{f}	12.95 (3.72)^{g}	8.94 (3.14)^{h}	17.88 (4.33)^{h}	9.93 (3.30)^{g}	8.37 (3.06)^{g}

07.00-08.00	9.06 (3.16)^{j}	19.12 (4.48)^{f}	23.38 (4.93)^{e}	16.26 (4.15)^{f}	31.10 (5.655)^{f}	21.07 (4.68)^{d}	17.15 (4.25)^{d}	10.45 (3.38)^{h}	17.94 (4.34)^{e}	23.71 (4.96)^{d}	20.93 (4.67)^{e}	16.42 (4.17)^{f}	13.90 (3.85)^{e}	10.92 (3.44)^{g}	18.17 (4.37)^{d}	20.86 (4.66)^{b}
08.00-09.00	27.18 (5.30)^{e}	41.27 (6.49)^{a}	37.61 (6.20)^{a}	25.41 (5.13)^{b}	27.49 (5.32)^{b}	20.06 (4.58)^{d}	26.08 (5.19)^{b}	22.07 (4.79)^{ef}	27.90 (5.36)^{b}	21.92 (4.77)^{e}	9.96 (3.30)^{g}	19.28 (4.49)^{e}	7.94 (2.98)^{i}	14.9 (3.98)^{f}	23.40 (4.93)^{b}	17.12 (4.25)^{d}
09.00-10.00	36.24 (6.09)^{c}	38.25 (6.25)^{b}	29.48 (5.51)^{c}	23.38 (4.93)^{c}	24.08 (4.99)^{c}	27.09 (5.29)^{c}	21.12 (4.69)^{c}	39.13 (6.32)^{a}	25.91 (5.17)^{c}	18.93 (4.45)^{f}	13.64 (3.82)^{f}	23.92 (4.98)^{d}	16.88 (4.22)^{d}	22.19 (4.81)^{d}	20.10 (4.58)^{c}	14.86 (3.97)^{e}
10.00-11.00	42.28 (6.57)^{a}	32.21 (5.75)^{c}	20.33 (4.61)^{f}	34.56 (5.95)^{a}	18.06 (4.35)^{a}	33.11 (5.82)^{b}	30.10 (5.56)^{a}	41.51 (6.51)^{a}	29.90 (5.54)^{a}	30.89 (5.63)^{c}	22.64 (4.85)^{d}	35.88 (6.06)^{b}	22.84 (4.87)^{b}	34.76 (5.97)^{a}	23.84 (4.97)^{b}	19.55 (4.53)^{bc}
11.00-12.00	39.26 (6.33)^{b}	27.77 (5.36)^{d}	31.51 (5.69)^{b}	26.43 (5.23)^{b}	23.07 (4.89)^{b}	28.09 (5.38)^{c}	26.08 (5.19)^{b}	31.10 (5.65)^{b}	28.90 (5.45)^{ab}	42.85 (6.61)^{a}	37.02 (6.15)^{a}	40.86 (6.45)^{a}	28.80 (5.45)^{a}	31.78 (5.71)^{b}	27.81 (5.35)^{a}	24.83 (5.07)^{a}
12.00-13.00	35.23 (6.01)^{c}	29.19 (5.48)^{d}	26.43 (5.23)^{d}	17.28 (4.27)^{e}	13.04 (3.74)^{e}	43.14 (6.63)^{a}	17.46 (4.29)^{d}	27.31 (5.31)^{c}	22.92 (4.88)^{d}	36.87 (6.14)^{b}	31.01 (5.64)^{b}	23.16 (4.91)^{d}	21.85 (4.77)^{b}	25.89 (5.18)^{c}	16.08 (4.12)^{e}	18.87 (4.45)^{c}
13.00-14.00	21.14 (4.69)^{f}	17.39 (4.28)^{g}	18.3 (4.38)^{g}	7.11 (2.84)^{k}	17.05 (4.24)^{k}	29.09 (5.47)^{c}	13.38 (3.78)^{f}	25.08 (5.09)^{d}	12.95 (3.72)^{f}	29.40 (5.50)^{c}	25.98 (5.18)^{c}	29.45 (5.51)^{c}	19.86 (4.56)^{c}	22.44 (4.835)^{d}	17.37 (4.28)^{de}	11.92 (3.58)^{f}
14.00-15.00	20.13 (4.59)^{f}	20.82 (4.66)^{e}	9.15l (3.18)^{l}	13.21 (3.76)^{h}	8.02 (3.00)^{g}	13.04 (3.74)^{f}	15.85 (4.09)^{e}	20.4 (4.62)^{f}	16.94 (4.22)^{e}	21.34 (4.72)^{e}	14.25 (3.89)^{f}	19.93 (4.56)^{e}	11.92 (3.58)^{g}	17.12 (4.25)^{e}	8.52 (3.08)^{h}	6.99 (2.82)^{h}
15.00-16.00	31.20 (5.66)^{d}	13.08 (3.74)^{h}	11.18 (3.48)^{k}	10.16 (3.33)^{i}	11.03 (3.46)^{i}	3.01 (2.00)^{i}	22.40 (4.83)^{c}	23.07 (4.89)^{de}	24.91 (5.08)^{c}	8.97 (3.15)^{i}	20.93 (4.67)^{e}	15.94 (4.10)^{f}	8.04 (3.00)^{i}	15.20 (4.01)^{f}	13.27 (3.77)^{f}	9.08 (3.17)^{g}
16.00-17.00	17.31 (4.27)^{g}	8.05 (3.00)^{j}	16.26 (4.15)^{h}	14.23 (3.89)^{g}	2.00 (1.73)^{g}	7.02 (2.82)^{g}	14.04 (3.87)^{f}	13.35 (3.77)^{g}	7.97 (2.99)^{i}	11.66 (3.55)^{g}	9.96 (3.30)^{g}	8.32 (3.05)^{h}	12.91 (3.72)^{f}	9.08 (3.17)^{h}	1.98 (1.72)^{j}	8.57 (3.08)^{g}
17.00-	11.07	10.06	12.2	8.13	9.03	5.26	7.02	8.69	10.96	10.13	13.95	4.98	6.95	15.89	7.16	2.98

18.00	(3.47)^{i}	(3.32)^{i}	(3.63)^{j}	(3.02)^{j}	(3.16)^{j}	(2.50)^{h}	(2.82)^{h}	(3.11)^{i}	(3.45)^{h}	(3.32)^{h}	(3.86)^{f}	(2.44)^{i}	(2.81)^{j}	(4.10)^{f}	(2.85)^{i}	(1.99)^{i}
SE(d)	**0.068**	**0.065**	**0.046**	**0.051**	**0.089**	**0.107**	**0.070**	**0.101**	**0.060**	**0.089**	**0.082**	**0.108**	**0.060**	**0.065**	**0.081**	**0.080**
C.D (P=0.05)	**0.142***	**0.136***	**0.096***	**0.107***	**0.185***	**0.224***	**0.145***	**0.211***	**0.125***	**0.186***	**0.172***	**0.224***	**0.124***	**0.135***	**0.168***	**0.167***

Conclusion

From the present study, it is inferred that nectar gatherers population was always higher than pollen gathering population. Hence this period was considered as honey flow season from January to April every year which is reaffirms that the *A. cerana indica* colonies could be very well exploited for honey gathering purposes during these months in Tamil Nadu. At the time of honey flow season, availability of various bee flora was higher compared to other season and therefore it could be studied in future to find out the suitable bee flora available in the locality to propagate and manage the plant species with an option of abundant nectar and pollen to overcome the problem during the dearth period for commercial apiculture.

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EXOPOLYSACCHARIDE (EPS) MEDIATED INTERGENERIC COAGGREGATION AS A MECHANISM OF SALT TOLERANCE IN MAIZE

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Abstract

Exopolysaccharides (EPS) produced by intergeneric coaggregates of Azospirillum and Paenibacillus as a mechanism of abiotic stress tolerance i.e salt tolerance was investigated. The PGPR often found in the rhizosphere of maize, Azospirillum and Paenibacillus were isolated. Exopolysaccharide production by both Azospirillum and Paenibacillus was facilitated using basal medium supplemented with fructose, potassium nitrate and glucose broth together with incorporation of 0.3M sodium chloride. Natural and artificial intergeneric coaggregates of Azospirillum and Paenibacillus were prepared using coaggregation buffer and various plant seed materials respectively. The application effect of the different formulations of Azospirillum and Paenibacillus cells, namely, the vegetative cells of Azospirillum and Paenibacillus and the natural and artificial coaggregates of Azospirillum and Paenibacillus on the enhancement of seed vigour index of maize and adhesion to maize roots was studied under in vitro condition. It was concluded that the application of natural coaggregates of Azospirillum and Paenibacillus augmented the survival of PGPR cells in maize, thereby alleviating soil salinity, resulting in improved productivity of rainfed maize crop under saline stress and contributing to sustainable agriculture.

Key words: *Exopolysaccharide; Intergeneric; Coaggregates; Azospirillum; Paenibacillus; Saline stress*

Introduction

Maize (*Zea mays* L.) is the major crop of the world and provides more nutrients for humans and animals than any other cereals (Salvador, 1997). It is a versatile crop, allowing it to grow across a range of agro-ecological zones *viz*., temperate, arid and semiarid. India is the sixth largest producer of maize in the world contributing 3 per cent of the global production. In India, Tamil Nadu is one of the leading state in the production of maize under semiarid condition and share 8 per cent of the national maize production. However, the productivity (yield ha^{-1}) of the same is very low with less than a tonne per ha whereas a potential of 3 tonnes per ha is possible. Of the several biotic and abiotic constraints, salinity, N and P nutrition and incidence of diseases are the major constraints which limit the global maize production under semi-arid condition. (El Komy, 2002; Akram *et al*., 2010).

Among the various abiotic stresses, soil salinity prevailing under semiarid condition, plays a vital role in limiting the growth and production of maize (Shannon *et al*., 1984). Salt stress involves both osmotic and ionic stress in crop plants (Munns, 2002). Phosphorus is generally deficient in saline soils and fixed as water insoluble calcium phosphate (Graham and Grieve, 1999). Fixation of phosphorus in saline soil eventually lead to the reduction in biological nitrogen fixation and the availability of other nutrients (Higaneshuar *et al*., 2002).

Hence, the future increase in maize production under semi arid condition must come from the same or even reduced land area and hence, the productivity of maize (yield ha^{-1}) must be greatly enhanced by providing additional nutrient inputs and alleviation of salt stress.

Now-a-days, maize production management strategies under saline stress soils mainly focus on chemical amelioration including the use of chemical fertilizers and pesticides at high rates to enhance the per hectare yield of the crop. Persistent and injudicious use of these chemicals have toxic effects on the non-target microorganisms of the soil and also cause undesirable changes in the environment. The biological approach has a great potential in supplying "N and P" nutritions and biocontrol of phytopathogens which eventually lead to sustainable production of maize grown under saline stress.

Rhizosphere bacteria that favourably affect the plant growth and yield of commercially important crops are now denominated as "plant growth promoting rhizobacteria" (PGPR) (Kloepper *et al*., 1980).

PGPR affect plant growth through direct promotion by producing and secreting plant growth promoting substances or by eliciting root metabolic activities by supplying biologically fixed nitrogen and through indirect promotion by acting against phytopathogenic microorganisms (Kloepper et al., 1989; Muller et al., 1989). Moreover, the PGPR produce abundant exopolysaccharides (EPS) which reduce the toxic ion uptake including sodium and produce stress specific proteins in plants under salt stress (Nadeem et al., 2006). Further, the rhizobacterial EPS acts as an elicitor for the induction of systemic resistance (ISR) in many crop plants (Kyungseok et al., 2008) and play a critical role in microbial cell aggregation, microcolony / biofilm formation on the surface of plant roots and thus enhanced the aggressive colonization of PGPR cells in the rhizosphere of host plants (Denny, 1995). The well known PGPR include bacteria belonging to the genera, namely, *Azospirillum, Azotobacter, Pseudomonas, Bacillus, Azoarcus, Klebsiella, Arthrobacter, Enterobacter, Serratia* and *Rhizobium* on non-legumes (Burdman *et al*., 2000).

Azospirillum and Paenibacillus sp are the two important PGPR genera that are frequently encountered from the rhizosphere of maize (Guemouri – Athmani et al., 2000; Von der Weid et al., 2000). The PGPR characteristics of the genus *Azospirillum*, has already been well established (Bashan *et al*., 2004). Besides, the EPS production and the EPS – mediated flocculation / coflocculation and plant root colonization of the genus *Azospirillum* have also been well documented (Sadasivan and Neyra, 1985). The Gram positive, spore forming bacteria viz., *Paenibacillus* sp., a phylogenetic variant of the genus *Bacillus* (Ash *et al*., 1994) has been described as an effective PGPR (Petersen *et al*., 1996) and the ubiquitous occurrence of same from the rhizosphere of maize has already been reported (Vonder weid *et al*., 2000). The PGPR characteristics of *Paenibacillus*, have been frequently reported (Gjung Kahng *et al*., 2001). Furthermore, the abundant EPS production by *Paenibacillus* and the EPS mediated biofilm formation and subsequent plant root colonization have been well described (Haggag, 2007).

Materials and Methods

ISOLATION OF *AZOSPIRILLUM* AND *PAENIBACILLUS* FROM THE RHIZOSPHERE OF MAIZE

Isolation of *Azospirillum* from the rhizosphere soil sample of Maize

Ten grams of air dried soil sample of maize rhizosphere was transferred to 90 ml sterile distilled water in a 250 ml Erlenmeyer flask and incubated on a rotary shaker (100 rpm) for 30 min at ambient temperature. The well mixed suspension was then diluted appropriately and 0.1 ml of the suspension was aseptically transferred into test tubes containing 10 ml of semisolid malate medium (Nfb) (Day and Dobereiner, 1976) and incubated at 35°C for 36-58 hrs to allow sub-surface pellicle formation. After the incubation period, the cotton plugs were replaced with sub seals and 10 per cent of the air was replaced with acetylene gas. Nitrogenase assay (C_2H_2 reduction) was checked

and quantified by gas chromatograph (Chemito, India) fitted with Flame Ionisation Detector (FID). *Azospirillum* cultures were isolated and enriched from the tubes which showed characteristic pellicle formation and nitrogenase activity.

Isolation of *Paenibacillus* from the rhizosphere soil sample of maize

Ten gram of air-dried rhizosphere soil sample of maize, collected from each location, was transferred to 90 ml of sterile distilled water in a 250 ml Erlenmeyer flask and incubated on a rotary shaker (100 rpm) for 30 min at ambient temperature. The well mixed suspension of each soil sample was subjected to serial dilution ranging from 10^{-1} to 10^{-7} dilution. One ml of the suspension, from dilution 10^{-6} to 10^{-7} was aseptically transferred to sterile petriplates and 15-20 ml of tryptic soy agar medium was poured, rotated in clockwise and anticlockwise direction for uniform distribution and incubated at 28 ± 2°C for 48 hrs. At the end of incubation period, *Paenibacillus* colonies which appeared as white and wrinkled were transferred to tryptic soy agar slants and maintained at 4°C for further study.

Exopolysaccharide (EPS) production by *Azospirillum* and *Paenibacillus* at 0.3 M NaCl level

To evaluate the exopolysaccharide (EPS) production of *Azospirillum* and *Paenibacillus* isolates, the basal medium of Neyra and Van Berkum (1977) together with supplementation of 8 mM fructose and 0.5 mM KNO3 and glucose broth (GB) (Englesberg and Ingraham, 1957) together with incorporation of 0.3 M NaCl concentration were used, respectively. 100 ml of above respective medium was dispensed into 250 ml Erlenmeyer flasks under sterilized condition. One ml culture of each *Azospirillum* and *Paenibacillus* isolates (1 x 10^7 CFU / ml) was added individually to their respective medium and incubated at 28± 2°C for one week. The broth was kept in a rotary shaker at 250 rpm for 15 min every day.

After the incubation period, the cells were harvested by centrifugation and used for the analysis of alkali stable polysaccharide. The supernatant was used for the analysis of water-soluble polysaccharide.

Estimation of Water-soluble polysaccharide

To 20 ml of the supernatant fraction, 60 ml of isopropyl alcohol was added the incubated at 40°C overnight to precipitate water soluble polysaccharide. The precipitate was collected by filtering through pre weighed Whatmann No.42 filter paper and dried in an oven at 70°C for 24 hrs (Sutherland and Wilkinson, 1971).

Estimation of Alkali Stable Polysaccharide

The harvested cells were washed with distilled water and one ml of 30 per cent potassium hydroxide was added. The contents were heated for 1 hr at 100°C over a water bath. It was then cooled to room temperature and 20 ml of ethyl alcohol was added. The mixture was thoroughly shaken and the precipitated polysaccharide was collected by centrifugation.

Analysis of Alkali Stable Polysaccharide

To estimate the alkali stable polysaccharide in the sample, anthrone method (Dubois et al., 1951) was employed. Five ml of the anthrone reagent was pipetted out into the tubes and 100 ml of the sample was added and the mixture was shaken. The tubes were closed and heated exactly for 10 min on a boiling water bath. Then, the tubes were cooled rapidly under tap water. The absorbance was measured in a Bausch and Lomb spectronic-20 colorimeter at 620 nm. The quantity of polysaccharide present in the sample was determined by referring to the standard graph prepared with glucose and expressed as µg of glucose released g^{-1} of cells (Nelson, 1944).

STUDIES ON THE INTEGENERIC CO-AGGREGATION MECHANISM OF *AZOSPIRILLUM* AND *PAENIBACILLUS* CELLS, ISOLATED FROM MAIZE RHIZOSPHERE

Preparation of Inoculum

The two efficient PGPR isolates of *Azospirillum* and *Paenibacillus*, obtained previously were grown in synthetic malate broth and glucose broth respectively, duly supplemented with 0.05% yeast extract (w/v), and peptone 0.1% (w/v), respectively in a shaking bath at 30 ± 2°C for 5 days to get stationary phase cultures of *Azospirillum* and *Paenibacillus* separately. Then, the medium was centrifuged at 5000 x g for 10 min to harvest the stationary phase cells and the pellets washed three times with 0.1 M phosphate buffer (pH 6.8). Finally, the cells were resuspended in the same buffer to a cell concentration of 1 x 10^7 CFU / ml by measuring the absorbancy at 420 nm for *Azospirillum* and 500 nm for *Paenibacillus polymyxa* and used as inoculum.

Preparation of Coaggregation Buffer (Grimaudo and Nesbitt, 1997)

The co-aggregation buffer was prepared as stated below:

1. 20 mM Tris-HCl buffer (pH 7.8)
2. 0.1 mM $CaCl_2$
3. 0.01 mM $MgCl_2$
4. 0.15 M NaCl and
5. 0.02% $NaNO_3$

Preparation of Plant Seed Extract

The following plant seed extracts, namely, *Moringa oleifera, Strychnos potatorum, Allium cepa, Sappindus emaginatus* and *Asteracantha longifolia* were prepared as stated below. Matured seeds of the above said plant seed materials were collected crushed and sieved (0.8 mm mesh). The seed powder is mixed with a small amount of sterile water to form a paste. Then, the paste is diluted to the required strength *viz.,* 5 per cent concentration before using it.

The insoluble materials are filtered out using either a fine mesh screen or muslin cloth. The clarified suspension of plant seed materials was used for co-aggregation studies.

Co-Aggregation Assay (Jabra-Rizk *et al.,* 1999)

One ml aliquot of each PGPR culture *viz., Azospirillum* and *Paenibacillus* was mixed in 10 ml Co-aggregation buffer. Uninoculated buffer served as control. The mixtures were vortexed for 10 seconds, shaken on a rotary platform shaker for 3 min. and left undisturbed at room temperature for 24 hrs. All Co-aggregation reactions were performed in triplicate.

Estimation of Co-Aggregation Percentage (Madi and Henis, 1989)

After the incubation period, the aggregates settled at the bottom of the tube while some of the free cells remained in suspension. The supernatant was sampled and its turbidity measured in spectronic-20 colorimeter at 420 nm. The flocs were then mechanically dispersed by treatments in a tissue homogenizer for 1 min and the total OD was measured and per cent co-aggregation was calculated as follows:

$$\% \text{ Co-aggregation} = \frac{OD_t - OD_s \times 100}{OD_t}$$

Where

OD_t = total optical density after mechanical dispersion and

OD_s = OD of supernatant after co-aggregate had settled

Induction of Artificial intergeneric Co-aggregation among PGPR cells

Effect of Different Plant seed Materials on Induction of Intergeneric Co-Aggregation among PGPR Cells under log phase

The PGPR isolates *viz., Azospirillum* and *Paenibacillus* were grown in respective broth and the cells were harvested at **log phase** as stated earlier. One ml aliquot of each PGPR isolate (1 x 10^7 cells / ml) was mixed in 10 ml of Co-aggregation mixture (Grimaudo and Nesbitt, 1997) together with the addition of one ml of individual plant seed extract *viz., Moringa oleifera, Strychnos potatorum, Allium cepa, Sappindus emaginatus* and *Asteracantha longifolia.* The mixture was vortexed for 10 seconds, shaken on a rotary platform shaker for 3 min and left undisturbed at room temperature for 1hr. The co-aggregation percentage was estimated according to Madi and Henis (1989).

Comparison of Natural and Artificial Co-aggregates of *Azospirillum* and *Paenibacillus* cells with respect to EPS Production at various time intervals

The PGPR isolates *viz., Azospirillum* and *Paenibacillus* were subjected to natural co-aggregation as detailed earlier and the same isolates were subjected to artificial co-aggregation separately by using plant seed flocculant (*Moringa oleifera*) as detailed earlier. The co-aggregation percentage (Madi and Henis, 1989), exopolysaccharide production (Dubois *et al.,* 1951) and spore count were estimated at different time intervals *viz.,* 0, 6, 12, 18, 24, 30, 36, 42 and 48 hr as detailed earlier.

Survival of *Azospirillum* and *Paenibacillus* cells in Natural and Artificial Coaggregates at various time intervals

The PGPR isolates *viz., Azospirillum* and *Paenibacillus* were subjected to natural and artificial coaggregation as detailed earlier. After the incubation period (48 hrs) the natural as well as artificial coaggregates with approximately with 40% and 30% PHB content respectively, were collected as wet floc and stored at 4°C and aliquots were periodically removed for viability measurements. Viability of the wet floc was determined by incubating 0.1ml of wet floc in 100 ml of 0.1 M phosphate buffer for 27-28 hrs. at room temperature. After the incubation period, 0.1 ml of the incubated floc was then plated for viable counts on semi selective nutrient agar (NB containing 1.5% agar and 15 μg/ml streptomycin) and incubated at 30 ± 2°C. Viability was determined by measuring the number of colonies forming units (CFU) per ml of wet floc.

Effect of Natural and artificial Co-aggregates of *Azospirillum* and *Paenibacillus* on seed vigour index of Maize

Maize (*Zea mays L.*) *cv.*CO 1 seeds were surface sterilized following the procedure mentioned earlier. The *Azospirillum* and *Paenibacillus* isolates were grown and harvested as described earlier and the natural and artificial coaggregates of the same isolates were prepared as described earlier. Surface sterilized healthy maize seeds (10 seeds / set) were treated with the following treatments.

1. Control (No inoculation)
2. 1 x 10^7 CFU / ml of *Azospirillum* vegetative cells (A-19).
3. 1 x 10^7 CFU / ml of *Paenibacillus* vegetative cells (B-19).
4. 1 x 10^7 CFU / ml of mechanically dispersed natural co-aggregates of *Azospirillum* and *Paenibacillus*.
5. 1 x 10^7 CFU / ml of mechanically dispersed artificial co-aggregates of *Azospirillum* and *Paenibacillus*.

The maize seeds were subjected to the above treatments, dried in shade for 30 min. Then, the inoculated maize seeds were arranged in two rows on a sheet of blotting paper dipped in sterile water. Then, they were covered with another blotting paper dipped in sterile water, rolled, and placed vertically in a moist chamber at 20°C. Uninoculated seeds with distilled water treatment served as control. After incubation for 5 days, each roll was opened and the vigour indices of germinated maize seeds were calculated by the method of Abdul-Baki and Anderson (1973).

Vigour index = Germination % x Total length of seedling (mm)
(Root and shoot length)

Effect of Natural and Artificial Co-aggregates of *Azospirillum* and *Paenibacillus* on adhesion with maize roots

The *Azospirillum* and *Paenibacillus* isolates were grown and harvested as mentioned earlier and the natural and artificialco-aggregates of the same isolates were prepared as detailed earlier. The growth of maize plants and the collection of maize roots were done according to the methodology mentioned earlier. The adsorption assay of *Azospirillum* and *Paenibacillus* cells in their different formulations *viz*., 1. Vegetative cells of *Azospirillum* and *Paenibacillus,* 2. Natural co-aggregates and 3. Artificial co-aggregates was carried out

Results & Discussion

Exopolysaccharide (EPS) production of *Azospirillum* and *Paenibacillus* isolates

It was found that the *Azospirillum* and *Paenibacillus* isolates were able to produce exopolysaccharides (EPS) at 0.3M NaCl level but with variation among them. The *Azospirillum* isolate, A-19 and *Paenibacillus* isolate, B-19 recorded the highest amount of EPS production (0.068 and 0.128g / 100 mL as water soluble polysaccharide, respectively and 5.726 and 6.826 glucose equivalent / g cell dry weight as alkali stable polysaccharide).

The study on the interstrain difference of *Azospirillum* and *Paenibacillus* isolates, grown under saline stress, revealed the distinct differences among the isolates with regards to exopolysaccharide (EPS) production. Haggag (2007) reported the elevation of soluble polysaccharides level with *Azospirillum* grown under salt stress condition. Haggag (2007) and Gjung-Kahng *et al* (2001) reported the EPS production by the isolates of *P. polymyxa.* However, no reports are available regarding the EPS production by *Paenibacillus* isolates grown under saline stress. In the present study, all the *Azospirillum* and *Paenibacillus* isolates were able to produce EPS, but with variation in the production of the same. The isolate A-19 (*Azospirillum*) and B-19 (*Paenibacillus*) relatively recorded more EPS production than others. The results clearly envisaged the existing of interstrain difference among *Azospirillum* and *Paenibacillus* isolates with regards to EPS production.

Table – 1

Interstrain difference of *azospirillum* and *paenibacillus* isolates on the production of exopolysaccharide (eps) at 0.3 m nacl concentration

Isolate	**Water soluble polysaccharide[c]**	**Alkali soluble polysaccharide[d]**
***Azospirillum*[a]**		
A-19	0.068 ± 0.24	5.726 ± 0.56
A-20	0.060 ± 0.29	5.494 ± 0.48
A-30	0.054 ± 0.18	4.968 ± 0.60

A-39	0.045 ± 0.15	4.747 ± 0.52
Paenibacillus [b]		
B-19	0.128 ± 0.34	6.826 ± 0.64
B-20	0.092 ± 0.27	6.452 ± 0.55
B-30	0.081 ± 0.29	6.157 ± 0.51
B-39	0.066 ± 0.22	5.866 ± 0.57

a – Inoculum level at 1×10^7 CFU/mL added to basal medium of Neyra and VanBerkum (1977) with fructose (8 m M concentration) and KNO_3 (0.5 m M concentration)

b – Inoculum at 1 x 10^7 CFU / mL added to Nutrient Glucose Broth.

c – g/100 ml

d – Glucose equivalent/g cell dry weight

Mechanism of Coaggregation

Cell aggregation is a widespread phenomenon in the microbial world and occurring under certain physiological conditions. Free living bacteria such as *Azospirillum* and *Paenibacillus* are known for their capacity to aggregate and this property positively affect the dispersal and survival of microbes in soil (Madi and Henis, 1989). Flocculation of microbial cells is the pre-requisite for encystations which plays a key role in survival of microbes under stress conditions. Neyra *et al* (1995), proposed the new generation of inoculants containing flocs of *Azospirillum* and R*hizobium* for common bean plants. Burdman *et al* (1998) studied the various physical and chemical factors which affect the aggregation in *Azospirillum brasilense*. Now, the concept of intergeneric coaggregation among bacterial species has been well developed and established (Malik and Kakil, 2003; Malik *et al.,* 2003; Malik *et al.,* 2004).

Factors Affecting the Artificial Coaggregation of Pgpr Cells

Effect of addition of plant seed material on coaggregation of PGPR cells under log phase

The effect of addition of different plant seed materials, namely, *Moringa oleifera, Strychnos potatorum*, *Allium cepa*, *Sappindus emaginatus,* and *Asteracantha longifolia* to the Co-aggregation buffer on the coaggregation percentage of PGPR cells was studied and the results presented in Table – 2.

It was observed that the addition plant seed materials to Co-aggregation buffer could augment the coaggreation of PGPR cells within a short period of time, namely, 1hr. Among the different plant seed materials, the seed materials from *Moringa oleifera* could augment the coaggregation of PGPR cells to a higher level followed by *Strychnos potatorum, Allium cepa, Sappindus emaginatus* and *Asteracantha longifolia.* There was a maximum of 98.5% coaggregation recorded with addition of *Moringa oleifera* while it was least (93.2%) with addition of *Asteracantha longifolia*. The results are statistically significant at 5% level.

Among the different plant seed materials tested, the seed material of *Moringa oleifera* induced maximum coaggregation percentage among PGPR isolates than other seed materials. The flocculating ability of *Moringa* seed materials has been discussed by few authors (Oluduro and Aderiye, 2007; Amagloh and Benang, 2009) and used the same primarily in water treatments.

Heller *et al*. (2000) emphasized the role *Moringa oleifera* seeds, as water clarifier and explained that the water-soluble proteins released from the crushed seed kernels functioned as natural flocculating agents. In the present study, the water-soluble protein released from the seed kernel of *Moringa oleifera* might be the reason for the coaggregation of PGPR cells.

TABLE – 2

Effect Of Addition Of Plant Seed Materials On Coaggregation[d] Of *Azospirillum* And *Paenibacillus* Isolates

Isolate, culture medium and growth phase[a]	Addition of plant seed material[b]	Percentage of coaggregation[c]
Azospirillum - nutrient broth (NB) - Log *Paenibacillus* - nutrient glucose broth (NGB) – Log	*Moringa oleifera* *Strychnos potatorum* *Allium cepa* *Sappindus emaginatus* *Asteracantha longifolia*	98.50 ± 0.1[a] 96.20 ± 0.3[b] 94.10 ± 0.2[c] 93.80 ± 0.3[d] 93.20 ± 0.5[e]

a – PGPR cells *viz*., *Azospirillum* (A-19) and *Paenibacillus* (B-19), collected from NB and NGB at log phase of growth used for co-aggregation assay at inoculum level of 10^7 : 10^7 CFU mL^{-1}.

b – Addition of plant seed material at a concentration of 5% level.

c – Assayed according to Madi and Henis (1989) after 24 hr of incubation time

d – Values followed by different letters are significantly differed at 5% level according to student "t" test.

Comparative study of natural and artificial intergeneric coaggregations of *Azospirillum* and *Paenibacillus* cells with respect to EPS and PHB production at various time intervals

A comparative study was made to reveal the efficiency of natural and artificial intergeneric coaggregation of *Azospirillum brasilense* (A-19) and *Paenibacillus polymyxa* (B-19) with respect to EPS and PHB production at various time intervals was studied and the results presented in Table – 3.

Between the two methods of coaggregation *viz*., natural, and artificial, the artificial coaggregation inducing by plant seed flocculant (*Moringa oleifera*) recorded the highest coaggregation percentage between 0-6 hr duration and steadily active up to 30th hr duration and thereafter no coaggregation occurred up to 48th hr of observation. In natural coaggregation method, there was no coaggregation recorded up to 12th hr in Co-Ag buffer and the coaggregation started at 12th hr of incubation and extended up to 42 hr. However, the coaggregation percentage was more (97 per cent at 42 hr) in artificial coaggregation whereas it was least (91 per cent at 42 hr) in natural coaggregation. However, the EPS and PHB production during the artificial coaggregation was less (1.87 Glucose equivalent / g cell dry weight of EPS production and 30.6 per cent of PHB content) at 48th hr of incubation, whereas it was more in natural coaggregates (2.21 Glucose equivalent/g of cell dry weight as EPS production and 40.4 per cent of PHB content) at 48th hr of incubation. Interestingly, in both the methods, the EPS production in the Co-Ag buffer started from 18th hr of incubation whereas the PHB production started at 30th hr. The results of the present study clearly revealed that the artificial coaggregation inducted by plant seed flocculant recorded a high coaggregation percentage in a short period of incubation but the EPS and PHB content of the coaggregates were found to be least when compared to natural coaggregates.

The results of the present study clearly revealed the efficiency of plant seed materials to augment the coaggregation of PGPR cells at log phase of growth with high coaggregation percentage in a short period of incubation. But, the EPS, PHB content and sporulation of the artificial coaggregates

were found to be less when compared to natural coaggregates. On the other hand, natural coaggregation of PGPR cells in Co-Ag buffer started only at 12th hr incubation extended upto 42 hrs whereas the level of EPS, PHB content and sporulation was found to be high when compared to artificial coaggregation (Table - 3).

TABLE – 3

Comparison of Natural and Artificial Intergeneric Co-Aggregation of *Azospirillum* and *Paenibacillus* with Respect to Eps and Phb Production at Various Time Intervals

Time intervals (in hours)	Natural co-aggregation[a]					Artificial co-aggregation[b]				
	Exopolysaccharide content					Exopolysaccharide content				
	Co-aggregation (%)	Water soluble EPS (g/100 ml)	Alkali stable EPS (Glucose equivalent/g cell dry weight)	PHB Content *** (in %)	Spore count (%)	Co-aggregation (%)	Water soluble EPS (g/100 ml)	Alkali stable EPS (Glucose equivalent/g cell dry weight)	PHB content*** (in %)	Spore count (%)
0	–	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	95.4	–	–	–	–
12	12.8	–	–	–	–	95.8	–	–	–	–
18	48.6	0.003	0.84	–	–	96.2	0.001	0.52	–	–
24	90.2	0.005	1.05	–	–	96.8	0.003	0.86	–	–
30	90.3	0.006	1.31	20.4	19.6	97.0	0.004	1.23	12.8	16.4
36	90.5	0.006	1.64	25.2	29.2	97.0	0.005	1.37	19.2	28.6
42	91.0	0.007	1.89	32.6	42.6	97.0	0.005	1.52	27.4	37.8
48	91.0	0.009	2.21	40.4	60.4	97.0	0.006	1.87	30.6	40.0

a PGPR cells *viz*., *Azospirillum* (A-19) and *Paenibacillus* (B-19) at stationary phase of growth, used for the co-aggregation assay in co-aggregation buffer at an inoculum level of $10^7 : 10^7$ CFU mL^{-1} with an incubation period of 48 hr.

b PGPR cells *viz*., *Azospirillum* (A-19) and *Paenibacillus* (B-19) at log phase of growth, used for the co-aggregation assay in co-aggregation buffer at an inoculum level of $10^7 : 10^7$ CFU mL^{-1} together with addition of *Moringa* seed powder at 5% concentration and with an incubation period of 48 hr.

Survival of *Azospirillum* and *Paenibacillus* cells in natural and artificial coaggregates at various time intervals

The survival of *Azospirillum* and *Paenibacillus* cells in natural and artificial coaggregates (wet flocculent) up to 6 months time interval was studied and the results presented in Table – 4. It was observed that there was an appreciable loss of cell viability throughout the 6 months period. Maximum viability was recorded during the first month (8.21 for *Azospirillum* and *Paenibacillus*) whereas least viability was recorded during the 6^{th} month (7.51 for *Azospirillum* and 6.00 for *Paenibacillus* respectively). Viability during the rest of the months was intermediary to these two levels. Moreover, it was found that artificial coaggregates had a comparatively lesser viability than natural coaggregates during these time intervals.

A comparative study was conducted on natural and artificial coaggregates of *Azospirillum* and *Paenibacillus* cells with respect to EPS and PHB production at various time intervals. In the present study, the natural coaggregation starts after 6 hr of incubation in co-aggregation buffer and extended up to 42 hrs. Whereas the artificial coaggregation completed within an hour after the addition of plant seed material of *Moringa oleifera*. The PHB and spore count was found to be more in natural coaggregation than artificial coaggregation. Sadasivan and Neyra (1985) reported that in *Azospirillum brasilense* natural aggregation starts after 6 hrs of growth in fructose and KNO_3 amended minimal medium. Bleakley et al. (1988) reported a high level of EPS and PHB production deering natural aggregation of *Azospirillum brasilense*. Haggag (2007) reported high spore count of *Paenibacillus polymyxa* during stress conditions. The results of the present study are also in conformity with the earlier findings of Sadasivan and Neyra (1985) and Haggag (2007).

The survival ability of *Azospirillum* and *Paenibacillus* cells (in natural and artificial coaggregates) was studied at various time intervals *viz.*, 0 to 6 months with a view to sort out the difference between natural and artificial coaggregates in terms of survival. The results of the present study clearly revealed the superiority of natural coaggregates in terms of survival over artificial coaggregates. Higher PHB content and spore count of natural coaggregates of PGPR cells might be the reason for the higher survival of *Azospirillum* and Paenibacillus cells. Kadouri, 2003; Haggag, 2007). The results of the present study clearly revealed the positive interrelationship between the PHB content and spore count with survivability of *Azospirillum* and *Paenibacillus* cells, respectively and in conformity with the above findings.

Table – 4

Survival of *azospirillum* and *paenibacillus* in natural and artificial coaggreates floc (wet flocculent) at various time intervals

Time interval (months)	Natural cofloc*		Artificial cofloc*	
	Azospirillum++	*Paenibacillus*++	*Azospirillum*++	*Paenibacillus*++
0	8.21	8.21	7.42	7.42
1	8.08	8.04	7.35	7.32
2	7.74	7.72	6.78	6.72
3	7.65	7.63	6.62	6.59
4	7.60	7.59	6.49	6.45
5	7.56	7.55	6.32	6.28
6	7.51	7.51	6.00	6.00

* *Azospirillum* and *Paenibacillus* at 1 x 10^9 CFU / mL inoculum level

++ log_{10} CFU / mL of viable cells

Effect of natural and artificial coaggregates of PGPR cells on the enhancement of seed vigour index of maize

The application effect of the different formulations of *Azospirillum* and *Paenibacillus* cells, namely, the vegetative cells of *Azospirillum* and *Paenibacillus* and the natural and artificial coaggregates of *Azospirillum* and *Paenibacillus* on the enhancement of seed vigour index of maize was studied under *in vitro* condition and the results presented in Table 5.

Among the different formulations of PGPR cells, the natural and artificial coaggregates of *Azospirillum* and *Paenibacillus* enhanced the seed vigour indices of maize to a higher level when compared to the vegetative cell forms of the same. Between the two vegetative cell forms, *Azospirillum* vegetative cells was found to augment the seed vigour index (12500) of maize to higher level when compared to *Paenibacillus* cells. Between the natural and artificial coaggregates of *Azospirillum* and *Paenibacillus* cells, the natural coaggregates of PGPR cells was found to augment the seed vigour index (16100) of maize to a higher level than the artificial coaggregates of the same. The study clearly indicated the efficiency of *Azospirillum and Paenibacillus* natural coaggregates on the enhancement of seed vigour index of maize than any other formulations of the same.

The phytostimulatory effect of *Azospirillum* cells has been already reported (Bashan *et al*. 2004). In the present study also, the application of natural PGPR coaggregates of *Azospirillum* and *Paenibacillus* cells augmented the seed vigour index of maize to a higher level than individual application of PGPR cells and emphasized the role EPS rich PGPR coaggregates on the augmentation of seed vigour index of maize and inconformity with findings of Neyra *et al.* (1999) *viz.*, vegetative cells, natural and artificial coaggregates.

Table – 5

Application Effect of Natural and Artificial Co-Aggregates of *Azospirillum* and *Paenibacillus* on the Enhancement of Seed Vigour Index of Maize

Treatment	Seed vigour index[b]	% over control	Statistics[a]
Control (uninoculated)	10450 ± 20.16	-	f
Azospirillum (A-19) vegetative cells^{+}	12500 ± 12.34	19.63	d
Paenibacillus (B-19) vegetative cells*	12410 ± 28.00	18.72	e
Azospirillum (A-19) and *Paenibacillus* (B-19) Co-inoculation**	14232 ± 16.28	36.54	c
Azospirillum + *Paenibacillus* Coaggregates (natural)**	16100 ± 9.07	54.04	a
Azospirillum + *Paenibacillus* Coaggregates (artificial)**	15430 ± 12.63	48.67	b

* – At 1×10^7 CFU/mL level of inoculum / seed.

** - At 1×10^7 CFU/mL level of inoculum / seed after mechanical dispersion.

a – Values followed by different letters are significantly differed at 5% level according to student 't' test.

b - Values are mean of three replication ± SD.

Effect of natural and artificial co-aggregates of PGPR isolates on the enhancement of adhesion to maize roots

The application effect of the different formulations of *Azospirillum* and *Paenibacillus* cells, namely, the vegetative cells of *Azospirillum* and *Paenibacillus* and the natural and artificial coaggregates of *Azospirillum* and *Paenibacillus* on the enhancement of adhesion to maize roots was studied under *in vitro* condition and the results presented in Table – 6.

Among the different formulations of PGPR cells, the natural and artificial coaggregates of *Azospirillum* and Paenibacillus enhanced the adhesion of maize roots to a higher level when compared to the vegetative cell forms of the same. Between the two vegetative cell forms, *Azospirillum* vegetative cells was found to augment the adhesion of maize roots (275.5 x 10^4 cells/g dry wt. of root/hr) to higher level when compared to *Paenibacillus* cells. Between the natural and artificial coaggregates of *Azospirillum* and *Paenibacillus* cells, the natural coaggregates of PGPR cells was found to augment the adhesion of maize roots (362.5 x10^4 cells/g dry wt. of root/h) of maize to a higher level than the artificial coaggregates of the same. The study clearly indicated the efficiency of *Azospirillum* and *Paenibacillus* natural coaggregates on the enhancement of adhesion of maize roots than any other formulations of the same.

The adhesion of *Azospirillum* cells has been reported by few authors (Sadasivan and Neyra, 1985; Burdman *et al*. 2000).

Michels *et al*. (1998) reported the poor adhesion of Floc mutant strains of *Azospirillum* cells to wheat roots and emphasized the positive role of EPS in the adhesion process. Sadasivan and Neyra (1985) reported the improved adherivesness of *Azospirillum* bioflocs with plant roots and suggested the role of EPS in the early events of adhesion to plant roots. The adhesion of EPS rich *Paenibacillus* cells to various plant roots has also been reported (Puente *et al*., 2009). The results of the present study clearly revealed the improvement in adhesion of EPS rich PGPR coaggregates (natural) to maize roots, when compared to PGPR coaggregates (artificial) and individual PGPR cells and emphasized the role of EPS in the early events of adhesion of PGPR isolates to maize roots.

Table – 6

Application effect of natural and artificial co-aggregates of *azospirillum* and *paenibacillus* on adhesion++ to maize roots under *in vitro* condition

Treatment	No. of adhered cells (10^4/g dry wt. of root/h)[a,b]
Azospirillum (A-19) Vegetative cell*	275.5 ± 3.93[c]
Paenibacillus (B-19) Vegetative cell*	200.2 ± 1.51[d]
Azospirillum + *Paenibacillus* Coaggregates (natural)**	305.0 ± 6.48[b]
Azospirillum + *Paenibacillus* Coaggregates (artificial)**	362.5 ± 7.25[a]

++ According to Gafni et al., (1986).

* at 1 x 10^7 CFU/mL inoculum level.

** at 1 x 10^7 CFU/mL inoculum level after mechanical dispersion.

a – Values are mean of three replications ± SD. b – Values followed by differed letters are significantly differed at 5% level according to student 't' test.

Conclusion

The coaggregation between *Azospirillum* and *Paenibacillus* cells, under natural condition, started at 12th hr of incubation of the same in coaggregation buffer and extended upto 42 hr whereas the artificial coaggregation of the same, inducted by plant seed material of *Moringa oleifera*, started immediately after the addition of the same to the coaggregation buffer and extended upto 24 hr. A maximum amount of PHB production and spore count was recorded with natural coaggregates of PGPR cells while it was low with artificial coaggregates at 48 hr of incubation. The survival of *Azospirillum* and *Paenibacillus* cells in PGPR coaggregates (natural) was found to be more during 6 months interval of time when compared to *Azospirillum* and *Paenibacillus* cells in PGPR co-aggregates (artificial). Higher level of PHB content and spore count of PGPR coaggregates (natural) might the reason for the same. The application of *Azospirillum* and *Paenibacillus* cells, as natural coaggregates, could augment the seed vigour index, adhesion to roots in maize when compared to the application of PGPR coaggreages (artificial) and vegetative cells of *Azospirillum* and *Paenibacillus*.

Addition of *Moringa oleifera* seed materials, as plant seed flocculant, induced a higher level of artificial coaggregation among *Azospirillum* and *Paenibacillus* cells at log phase of growth followed by *Strychnos potatorum*, *Alliumcepa*, *Sappindus emaginatus* and *Asteracantha longifolia*.

The application of "Intergeneric coaggregates of *Azospirillum* and *Paenibacillus*" cells under natural condition together with application of 75 per cent recommended dose of N and P levels in CO 1 maize recorded the growth and yield parameters on par with 100 per cent recommended N and P fertilizers application without any bioinoculation treatment and thus a saving of 25 per cent recommended N and P fertilizers could be achieved through the application of intergeneric PGPR coaggregates (natural) in rainfed maize crop. Moreover, the natural co-aggregates application augmented the survival of PGPR cells in maize rhizosphere thereby alleviating soil salinity.

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GENETIC VARIABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS FOR YIELD ATTRIBUTING CHARACTERS IN CHILLI

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Abstract

In chilli India is the leading producer, consumer and exporter but lower the productivity. To increase productivity, it is necessary to develop superior varieties or hybrids. The efficiency of selection depends upon the nature and significance of genetic variability and degree of contagious of desired characters. Because yield is a complex character, its direct improvement is difficult. Eight genotypes of chilly were evaluated for yield and a few related characters in a field experiment in randomized block design (RBD) with three replications during Kharif, 2021-2022 in Palar Agricultural College (PAC) affiliated through TNAU, Coimbatore, in Vellore, Tamil Nadu. Analysis of variance (ANOVA) revealed significant difference among varieties for all the characters studied. High genotypic coefficient of variation, heritability in broad sense and genetic advance estimated for the charactersviz. Fruits per plant, flowers per branch, and clusters per plant, fruit weight and days to flower at 50% indicated the scope for improvement of these characters through selection. Fruits per plant had significant positive correlation with fruit length (0.35), days to 50% flower, flowers per branch, and fruits per branch. Fruit weight had significant positive correlation with fruit breadth (0.56) and stem diameter. These characters may be given more emphasis for direct selection of high yielding chilli genotypes in future breeding programmes.

Key words: *Genetic variability, Heritability, Genetic advance, Correlation, Path Coefficient and Yield*

Introduction

Chilli (*Capsicum annuum* L.) originated from central-east Mexico and northeastern Mexico and belongs to the Solanaceae family with diploid chromosome number 2n = 2x = 24. It is a spice, a fruit vegetable widely cultivated in the world and its importance in human food is capital (Dias *et al*., 2013). Chilli valued for its aroma, taste, pungency, and flavor. Wide ranges of variability reportedly exist in this crop (Nandi, 1992; Munshi and Behera, 2000). Most of the agronomic characters in crop plants are quantitative in nature. Yield is one such character that results due to the actions and interactions of various component characters (Grafius, 1960). It is also widely recognized that genetic architecture of yield can be resolved better by studying its component characters. This enables the plant breeder to breed for high yielding genotypes with desired combinations of traits (Khan and Dar, 2009). Cultivation in small holdings by individual farmers under diverse environmental conditions is through to have contributed for this vast variability; this also implies the potential for utilizing such variability in crop improvement programmes. The current study was undertaken with the aim of estimating genetic variability, heritability, genetic

advance, correlation and path coefficient of chilli, for improving the yield and yield attributing characters.

Materials and Methods

The chilli genotype collected from various part of India. The materials for the study comprised of eight cultivars PC25, PC7, PC2057, PC10, PC1, LCA334, KA2 and PC56 of chilli of which six were GBPUA&T, Pantnagar, one cultivars KA2 from Guntur, Andhra Pradeshand one local cultivars from Uttarakhand LCA 334 developed through pure line selection from indigenous germplasm. The cultivars were raised in a field experiment in randomized block design (RBD) with three replications in the Palar Agricultural College (PAC), Kothamarikuppam, and Vellore during, 2021-22 (Affiliated through TNAU, Coimbatore). The chilli crop planted a normal spacing of 60 cm x 30 cm, as per the TNAU, Coimbatore package of practices were followed to raise a crop. Data on plant weight, branch per plant, fruits per plant, fruit weight, fruits length, fruit breadth, days to 50% following, flowers per branch, fruit per branch, cluster per plant and stem diameter were recorded from five randomly selected plant at maturity stage from each genotype. The genetic parameters *viz*., phenotypic co-efficient of variation (PCV) and genotypic coefficient of variation (GCV), correlation and path coefficient analysis of chilli (Table 4) were estimated. The heritability in broad sense and genetic advance as percentage of mean were estimated employing the methods, suggested by Miller *et al* (1958) and Jain (1982) respectively. Each genotypes twenty plants per plot in each replication were planted. Data was recorded on plant weight, branch per plant, fruit per plant, fruit weight, fruit length, fruit breadth, days to flowering at 50% flowering, fruit per branch, cluster per plant and stem diameter. Statistical analyses for calculation of correlation were worked out s per Aljiburl *et al*, and path coefficient of various characters were calculated according to Deway and Lu.

Results and Discussion

The analysis of variance (Table 2) revealed significant difference among the genotypes for all the characters studied except fruit breadth, stem diameter and clusters/plant. The existence of high variability for different characters among chilli genotypes had been earlier studied by sreelathakumary, I and Rajmony, L, 2004. The genetic parameters *viz,* genotypic and phenotypic coefficient of variations, heritability in broad sense and genetic advances along with mean and range of different characters are presented in Table 1. The wide range especially for fruit per plant, fruit weight, flowers per branch, fruit per branch, cluster per plant indicated the diversity among the chilli genotypes. Yield of chilli fruit weight recorded the highest phenotypic and genotypic coefficient of variation followed by fruit per plant and flower per branch. This suggested the scope for improvement of these characters through selection. High GCV and PCV for flowers per branch, cluster per plant, fruit per branch, stem diameter and fruits per plant were earlier reported by several workers Data, S and Das, L, 2013.Heritability estimates were high and medium for all the characters studied.

The values were especially high for flowers per branch, cluster per plant, fruit per plant and stem diameter. High heritability for fruit per plant and cluster per plant reported by Gopalakrishnan, T. R *et al*, 1984 supported the present findings. Further, similar to the present results, high heritability for fruit weight, days to 50% flower and fruit per branch was reported by Pandit, M.K and Adhikary, S respectively. Johnson *et al.* (1955) suggested that high heritability combined with high genetic advance is indicative of additive gene action and selection based on these parameters would be more reliable. In the present investigation, high heritability estimates in conjunction with high genetic advances were observed for fruit per plant, flowers per branch, fruit weight, cluster

per plant and days to flower at 50% Choudhary, B.S and Samadia, D.K, 2004 and Ukkund, K.C *et al*, 2007 reported high heritability and high genetic advance for fruit per plant and fruit weight. In view of the high estimates of genotypic coefficient of variation, heritability and genetic advance recorded for fruit per plant, flower per branch, fruit weight, cluster per plant and days to flower at 50% in the present study, it is concluded that the improvement in these characters can be achieved through selection.

Correlation and path coefficient matrix of different characters is given Table 4. The genotypic coefficient of correlation in general was high in magnitude than phenotypic correlation coefficient indicating a strong inherent association among various characters. It's supported by Chaudhary *et al* (1985), Leayajose and Abdul khader (2000). Plant weight had significant positive correlation with branch per plant (0.25), fruit weight (0.33), flowers per branch (0.41), clusters per plant (0.22), stem diameter (0.42) but simultaneously a significant but negative correlation was present days to 50% flower, and this negative significant gave early days to maturity. Also reported by Hiremath (1997), Leayajose and Abdul khader (2002). Branches per plant had significant positive correlation with fruit weight (0.88), fruit breadth (0.64), and days to 50% flower (0.33). A significant but negative correlation was present between flowers per branch, fruits per branch and cluster per plant, same result reported by Rani *et al*. (1996) and Gogoi and Gautam (2003). Fruits per plant had significant positive correlation with fruit length (0.35), days to 50% flower, flowers per branch, and fruits per branch. A significant but negative correlation was present between cluster per plant (-0.83) and fruit breadth (-0.23) also reported by Warad *et al* (1997), Gupte and Singh (1992), Munshi*et al* (2000) and Vikram*et al* (2014).

Fruit weight had significant positive correlation with fruit breadth (0.56) and stem diameter. A significant but negative correlation was reported days to 50% flower (-0.06), flowers per branch (-0.41), fruit per branch (-1.07) and cluster per plant (-0.30). Gogoi and Gowtham (2003), Hari*et al*, (2005), karad*et al.* (2006) and chatargee*et al* (2007). Fruit length had significant positive correlation with fruit length 90.28), fruit breadth (0.91), flowers per branch (0.65), fruits per branch (0.84), stem diameter (0.70). a significant but negative correlation was days to 50% flower (-0.25) and cluster per plant (0.57). Gandhi (1998) and Mehrotra *et al* (1977) also reported the similar result. Fruit length had significant positive correlation with fruit length (0.28), fruit breadth (0.91), flowers per branch (0.65), and fruits per branch (0.84) stem diameter (0.70). A significant but negative correlation was days to 50% flower (-0.25) and cluster per plant (-0.57).

Fruit breadth had significant positive correlation with days to 50% flowering but negative significant correlation with fruit per branch and cluster per plant. Flowers per branch had significant and positive correlation with fruit per branch (0.96) and stem diameter (0.36). The analysis of path coefficient (Table 4) was portioned into direct and indirect effect with help of path analysis. To confirm these findings genotypic and phenotypic correlation coefficient were partitioned into direct and indirect effect with help of path analysis. Path analysis recorded that plant weight had positive direct effect on fruit per plant followed by stem diameter and fruit weight. Contrary this, plant weight had direct effect in negative direction flowed by fruit length, fruit breadth, days to 50% flowering, cluster per plant and fruit per branch. Munshi *et al* (2000) also reported the similar result. Number of branches had direct effect on fruit per plant (0.25), fruit breadth (0.44), and flower per branch (0.82) and fruit weight (0.88). in contrary number of branches had indirect effect on number of branch, days to 50% flowering and stem diameter and cluster per plant. Singh *et al*, 1981, Aliyu*et al*, 2000 and Ahmed *et al*. 1997 also reported similar result.

Fruit per plant had direct effect on fruit length, fruit per branch and stem diameter. In contrary indirect effect on days to 50% flowering. Rathod*et al* and Khurana*et al* also reported similar result. Fruit length had direct effect on fruit breadth, fruit per branch a stem diameter, in contrary stem diameter, number of branch and plant weight indirect effect. Fruit breadth had direct effect on fruit length, fruit breadth, and flower per branch and fruit weight. In contrary indirect effect on plant weight, number of branch, days to 50% flowering, cluster per plant and stem diameter. Choudhary*et al.* Days to 50% flowering had direct effect on fruit breadth, flower per branch and stem diameter. In contrary direct effect on days to 50% flowering. Kumar *et al*, (2011), Kaul and Sharma (1989) and Verma*et al* (2004) also reported similar result. Fruit weight had direct effect on number of breadth, fruit per plant, flower per branch, fruit per branch, cluster per plant, stem diameter, fruit per plant. In contrary indirect effect on fruit branch and days to 50% flowering. Warade *et al* (1997), Khurana *et al* (2003), Gogoi and Gautham (2003), Mathew *et al* (2004), Choudhary and Samadia (2004) and Kharad *et al* (2006) and Mishra *et al* (2004) also reported similar result.

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Table 1: Genetic variation, heritability and genetic advance for different characters in chilli

Characters	Mean	Range	Variance		Coefficient of variance		h^2 (%)	Genetic advance	
			Genotypic	Phenotypic	GCV (%)	PCV (%)	Broad sense	GA %	As (%) Mean
Plant weight	74.16	62.3-80.3	30.31	51.09	7.42	9.64	59.00	21.19	35.09
Branches/plant	15.50	13.3-17.33	1.25	2.73	7.22	10.66	46.00	32.0	22.92
Fruit per plant	106.33	90.0-120.3	140.21	218.4	11.14	13.90	64.00	65.04	53.55
Fruit weight	241.50	214.0-279	313.8	675.8	7.34	10.76	46.00	61.87	63.20
Fruit length	8.08	7.00-9.33	0.59	1.55	9.53	15.40	38.00	52.06	55.70
fruit breadth	2.72	2.43-3.16	0.04	0.11	7.65	12.22	39.00	64.00	52.64
Days to fl. at 50%	44.62	42.6-49.33	3.42	6.91	4.15	5.89	50.00	43.44	57.71
Flowers/branch	47.12	30.6-63.3	103.5	158.3	21.59	26.70	65.00	51.72	46.09
Fruits/branch	46.08	24.66-53.6	60.87	126.8	16.93	24.44	48.00	52.70	60.96
Cluster/plant	34.54	22.3-45.66	44.27	68.98	19.26	24.04	64.00	40.70	40.74
Stem diameter	2.29	1.78-2.83	0.13	0.20	15.49	19.26	65.00	27.50	32.88

Table 2: Analysis of variance for chilli genotypes

Characters	df	Plant weight	Branches/ plant	Fruits / plant	Fruit weight	Fruit length	Fruit breadth	Days to 50% flowering	Flowers/ branch	Fruits/ branch	Clusters/ plant	Stem diameter
Replication	2	6.94**	1.57*	723.76**	89.76**	1.13*	0.05	17.54**	124.12**	25.12**	0.44	0.24
Genotype	7	111.71**	5.23**	498.85**	1303.52**	2.73**	0.97	13.75**	365.32**	248.54**	157.51**	0.44
Error	14	20.78	1.47	78.23	361.95	0.95	0.67	3.48	54.79	65.94	24.70	0.06

Table 3: Mean performance of different genotypes of chilli

Chara cter	Plant weigh t	Bran ches/ plant	Fruits/ plant	Fruit weight	Fruit lengt h	Frui t brea dth	Days to 50% flower ing	Flowers /branch	Fruits /branch	Clust ers / plant	Stem diame ter
PC 25	78.33	17.33	90.00	279.00	7.00	2.83	45.00	30.66	24.66	36.66	02.16
PC 7	62.33	16.00	119.66	237.00	8.66	3.16	49.33	37.33	44.00	22.33	02.33
KA 2	78.66	15.33	111.66	255.33	8.00	2.50	44.00	43.66	51.00	31.33	02.83
PC 2057	68.33	15.33	97.33	232.33	8.00	2.63	43.00	44.66	50.66	42.33	01.78
PC 10	73.33	13.33	97.66	214.00	7.33	2.50	43.66	43.66	48.33	45.66	01.86
PC 1	77.33	16.66	94.00	244.33	9.33	2.96	42.66	63.33	53.66	35.00	02.26
LCA 334	80.33	16.00	120.33	219.33	7.00	2.43	45.66	55.33	48.66	32.00	02.26
PC 56	74.66	14.00	120.00	250.66	9.33	2.73	43.66	58.33	47.66	31.00	02.83
Mean	74.16	15.50	106.33	241.56	8.08	2.72	44.62	47.12	46.08	34.54	02.29
S.E.	2.632	0.701	005.10	10.98	0.56	0.14	01.07	04.27	04.68	02.86	00.15
C.D 5%	7.983	2.128	015.48	33.31	1.71	0.45	03.26	12.96	14.22	08.70	00.45

Table 4: Phonotypic, genotypic, correlation and path coefficient of chilly among different characters over the years

Character		Plant weight	Branches/ plant	Fruits/ plant	Fruit weight	Fruit length	Fruit breadth	Days to 50% flowering	Flowers/ branch	Fruits / branch	Clusters/ plant	Stem diameter
Plant weight	P	1.00										
	G	1.00										
Branches/ plant	P	0.08	1.00									
	G	0.25*	1.00									
Fruits/ plant	P	-0.11	-0.30**	1.00								
	G	-0.19	-0.23*	1.00								
Fruit weight	P	0.16	0.21*	-0.12	1.00							
	G	0.33**	0.88**	-0.39**	1.00							
Fruit length	P	-0.10	-0.13	0.08	-0.08	1.00						
	G	-0.53**	-0.08	0.35**	0.35**	1.00						
Fruit breadth	P	-0.44**	0.29**	0.12	0.17	0.28**	1.00					
	G	-0.68**	0.64**	-0.23*	0.56**	0.91**	1.00					
Days to 50% flower	P	-0.30**	0.21*	0.38**	-0.06	0.02	0.11	1.00				
	G	-0.70**	0.30**	0.65**	-0.01	-0.25*	0.88**	1.00				
Flowers / branch	P	0.22*	-0.06	0.17	-0.41**	0.45**	-0.02	-0.30**	1.00			
	G	0.41**	-0.32**	0.29**	-0.26*	0.65**	-0.24*	-0.60**	1.00			
Fruits/ branch	P	-0.20*	-0.36**	0.18	-0.22*	0.13	-0.28**	-0.15	0.42**	1.00		
	G	0.04	-0.56**	0.41**	-1.07**	0.84**	-0.22*	-0.49**	0.96**	1.00		

Clusters/ plant	P	0.21*	-0.24*	-0.57**	-0.18	-0.22*	-0.32**	-0.46**	0.08	0.06	1.00	
	G	0.22*	-0.41**	-0.83**	-0.30**	-0.57**	-0.73**	-0.95**	-0.11	0.01	1.00	
Stem diameter	P	0.11	-0.15	0.59**	0.32**	0.19	0.09	0.07	0.14	0.18	-0.54**	1.00
	G	0.42**	0.06	0.61	0.53**	0.70**	-0.09	0.10	0.36**	0.03	-0.76**	1.00

Fig 1: Genotypic coefficient of variability and phenotypic coefficient of variability of chilli

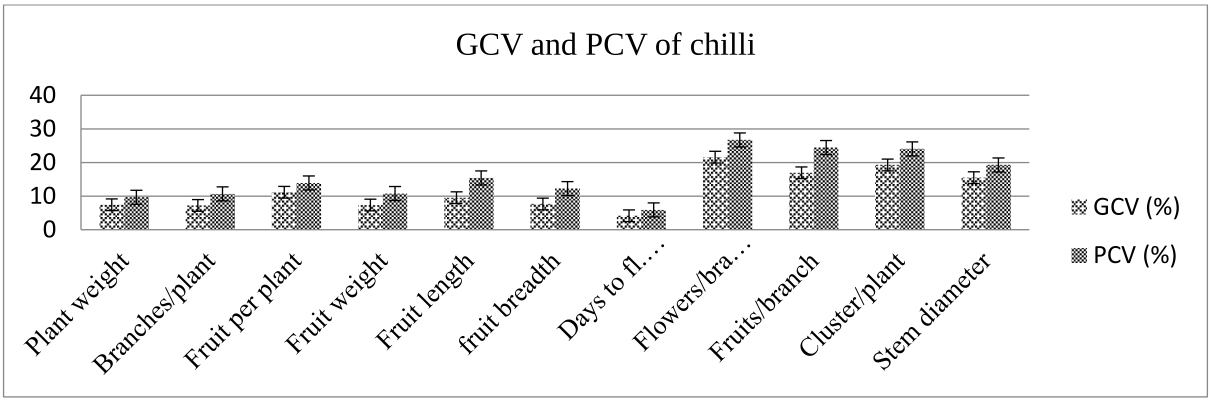
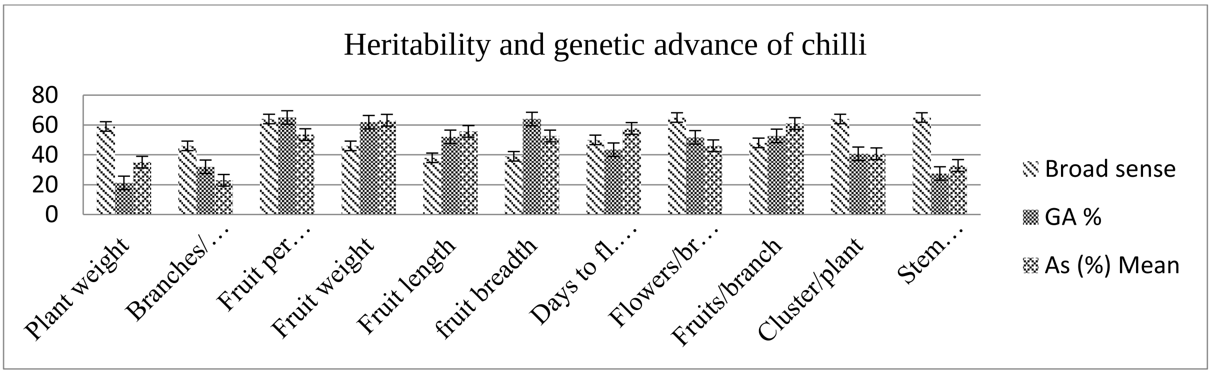


Fig 2: Heritability and genetic advance of chilli genotypes



MANAGING WEEDS FOR SUSTAINABLE PRODUCTION OF DIRECT SEEDED RICE IN THE EMERGING CASES OF HERBICIDE RESISTANCE

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Abstract

In the recent past, herbicide resistant weeds are increasing and creating a huge loss to the crop yields. In the experiments conducted at the Zonal Agricultural Research Station, Bangalore, it was found that the weeds, Echinochloa colona and Eleusine indica were reported to exhibit resistance to the most popular herbicide pyrazosulfuron ethyl 20 g a.i./ha. Hence, an experiment is conducted for the assessment of best herbicide for managing weeds in the emerging cases of herbicide resistance in direct seeded rice. With respect to the control of herbicide resistant Echinochloa colona and Eleusine indica, the herbicides, quizalofop-p-ethyl, cyhalofop-p-butyl, metamifop and bispyribac sodium were reported to reduce the weed density significantly. When the total weed density is considered, herbicide bispyribac sodium 10 SC 40 g a.i./ha as post emergence was reported to perform better followed by bensulfuron methyl + pretilachlor 6.6 G 660 g a.i./ha as pre emergence. The weed control efficiency, absolute growth rate, crop growth rate, dry matter production (g/hill), number of grains per panicle, grain and straw yield were also reported to be higher in bispyribac sodium 10 SC 40 g a.i./ha as post emergence was and was statistically on par with bensulfuron methyl + pretilachlor 6.6 G 660 g a.i./ha as pre emergence. Hand weeding at 20 and 40 DAS has recorded lowest weed density and higher crop growth and yield parameters. Unweeded control has recorded highest weed density and lowest crop growth and yield parameters.

Key words: *Herbicides, herbicide resistance, allelochemicals, direct seeded rice,*

Introduction

Rice is the most important source of food in India, providing 43 per cent of the calorie requirements for more than two-thirds of the population (Kaur and Singh, 2017) and 55 per cent of cereal production in the country. Herbicides are the most extensively used pesticides globally. Unfortunately, this useful tool has been challenged by the evolution of herbicide resistance in weeds in the recent past. Over-reliance on herbicides for weed control and reduced adoption of other preventive and cultural weed control practices resulted in the evolution and spread of herbicide resistant weeds.

The major problem in the success of direct-seeded rice in the tropical countries is that of heavy weed infestation due to successive emergence of weeds and crop at the same time. As weeds arise almost simultaneously as that of the crop in the direct seeded rice the weed competition with rice crop is greater, hence weed management by herbicide is more crucial (Singh and Singh, 2010). From the previous experiments, it is confirmed that the most common weeds of rice crop *viz.*, *Echinochloa colona* (jungle rice) and *Eleusine indica* (goose grass) were showing resistance to pyrazosulfuron ethyl at the recommended doses of 20 g a.i./ha. In this context, as there is a need to identify and analyze some alternative weed management strategies, an experiment is planned for the assessment of best herbicide for managing weeds in the emerging cases of herbicide resistance in direct seeded rice. Apart from the chemical alternatives, an eco-friendly weed management approach *i.e*., allelochemicals were also taken into consideration and three allelochemical treatments were included in the treatments.

Materials and Methods

A field investigation was carried out during *Rabi*, 2020 and *summer*, 2021 in the red sandy loams of Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences, Bengaluru, and Karnataka. In order to manage weed flora (including herbicide resistant weeds), twelve herbicide treatments including seven different herbicides, three different aqueous allelochemical extracts along with a hand weeding and unweeded control were selected for testing under direct seeded rice (**Table 1**). The field experiment was laid out in RCBD replicated thrice

Table 1. Treatment details

Treatment No.	Treatment description	Herbicide dose	Time of application
T_1	Bensulfuron methyl + pretilachlor 6.6 G 660 g a.i./ha	10,000 g/ha	PE
T_2	Pyrazosulfuron ethyl 10 WP 40 g a.i./ha	400 g/ha	PE
T_3	Oxadiargyl 80 WP 100 g a.i./ha	125 g/ha	PE
T_4	Bispyribac sodium 10 SC 40 g a.i./ha	400 g/ha	PoE
T_5	Quizolofop-p-ethyl 15 EC 37.5 g a.i./ha	250 g/ha	PoE
T_6	Cyhalofop-p-butyl 10 EC 100 g a.i./ha	1000 g/ha	PoE
T_7	Metamifop 10 EC 100 g a.i./ha	1000 g/ha	PoE
T_8	*Leucas aspera* plant extract	10 % w/v	PoE
T_9	*Eucalyptus* leaf extract	10 % w/v	PoE
T_{10}	*Hyptis saveolensis* plant extract	10 % w/v	PoE
T_{11}	Hand weeding	-	20 and 40 DAS
T_{12}	Unweeded control	-	-

Note: PE- Pre emergence, PoE- Post emergence

The herbicides were applied using spray volume of 750 L/ha for pre-emergence and 500 L/ha for post emergence with knapsack sprayer having flood jet nozzle. Seeds of rice variety, '*MAS 946-1*' were line sown with 30 cm space between the lines and the recommended dose of fertilizer *i.e.*, 100-50-50 kg of N, P_2O_5 and K_2O was applied with three splits of nitrogen. Observations on weed density and weed dry matter were recorded in an area of 0.25 m^2 and converted to 1 m^2. The data on weed density (no. m^{-2}) were transformed by using square root ($\sqrt{x+1}$) transformation as suggested by Gomez and Gomez (1984). The transformed data were subjected to Fisher's method of "Analysis of Variance" (ANOVA) as outlined by Panse and Sukhatme (1954). Wherever F- test was significant, for comparison between the treatment means, an appropriate value of critical difference (CD) was worked out. Growth analysis of the crop is analyzed by estimating absolute growth rate (gram of dry matter produced per day) and crop growth rate (gram of dry matter produced per unit area in a day). Yield parameters and yield were recorded at harvest and the economics were worked out based on the cost of inputs, labour charges and prices of outputs during the course of investigation. All the data presented in this paper was the mean of two seasons and the results are presented and discussed at a probability level of 5 %.

Results and Discussion

Weed density

The density of sedges, herbicide resistant *Echinochloa colona* and *Eleusine indica*, total grasses, broad leaf weeds (BLW) and total weeds were significantly influenced by the weed management practices in direct seeded rice and the data is presented in Table 2.

With respect to the control of herbicide resistant *Echinochloa colona* and *Eleusine indica*, the herbicides, quizalofop-p-ethyl, cyhalofop-p-butyl, metamifop (grass killers) and bispyribac sodium were reported to reduce the weed density significantly. But, when it comes to total weed density, the grass killers were likely to record higher values as they were narrow spectrum herbicides and were supposed to target only grasses but not sedges and broad-leaved weeds. For a successful crop production, weeds belonging to all the categories needs to be controlled. Bispyribac sodium is a broad-spectrum systemic herbicide and has controlled major grasses (including herbicide resistant *E. colona* and *E. indica*), sedges and broad leaf weeds of rice, hence it has recorded lowest total weed density among the herbicidal treatments and the results were in line with the findings of Suresh *et al.* (2013) and Prakash *et al*. (2017). Application of chemical herbicides has resulted in better reduction in weed density compared to allelochemicals.

Table 2. Effect of different weed management practices on the weed density of direct seeded rice at 45 DAS

Treatments	Sedges	*Ec*	*Ei*	Total grasses	Total BLW	Total weeds
T_1	1.62(1.7)	1.52(1.3)	1.92(2.7)	1.05 (9.3)	3.06 (8.3)	1.33 (19.3)
T_2	2.36(4.7)	1.83(2.4)	1.92(2.7)	1.09 (10.4)	3.17 (9.0)	1.41 (24.0)
T_3	2.51(5.4)	1.83(2.4)	2.07(3.3)	1.15 (12.0)	3.28 (9.8)	1.46 (27.1)
T_4	2.15(3.7)	1.41(1.0)	1.73(2.0)	0.92 (6.3)	2.89 (7.3)	1.28 (17.3)
T_5	3.65(12.4)	1.41(1.0)	1.62(1.7)	0.86 (5.3)	5.25 (26.7)	1.67 (44.3)
T_6	3.56 (11.7)	1.62(1.7)	1.52(1.3)	0.88 (5.7)	4.67 (20.9)	1.60 (38.3)
T_7	3.51 (11.4)	1.41(1.0)	1.62(1.7)	0.79 (4.3)	4.71 (21.3)	1.59 (36.9)
T_8	3.36 (10.3)	2.82(7.0)	3.00(8.0)	1.49 (29.0)	4.67 (20.9)	1.79 (60.2)
T_9	3.05(8.3)	2.71(6.4)	2.82(7.0)	1.44 (25.7)	4.31 (17.6)	1.73 (51.6)
T_{10}	3.16(9.0)	2.77(6.7)	2.88(7.3)	1.46 (26.6)	4.53 (19.6)	1.76 (55.2)
T_{11}	1.30(0.7)	1.00(0.0)	1.00(0.0)	0.48 (1.1)	1.02 (0.0)	0.57 (1.8)
T_{12}	3.78 (13.4)	3.32(10.0)	3.46(11.0)	1.70 (48.4)	6.09 (36.3)	2.00 (98.0)
C.D (p=0.05)	0.55	0.36	0.39	0.18	0.87	0.12

Data within the parentheses are original values; Ec- *Echinochloa colona*, *Ei- Eleusine indica*

Weed control efficiency

Among herbicide treatments, highest weed control efficiency at 45 DAS and at harvest (Fig 1) was recorded in bispyribac sodium 10 SC 40 g a.i./ha as post emergence (95.00 and 71.21 %, respectively) followed by bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i./ha as pre-emergence (93.17 and 69.93 %, respectively). Higher weed control efficiency in these treatments were due to broad spectrum weed control.

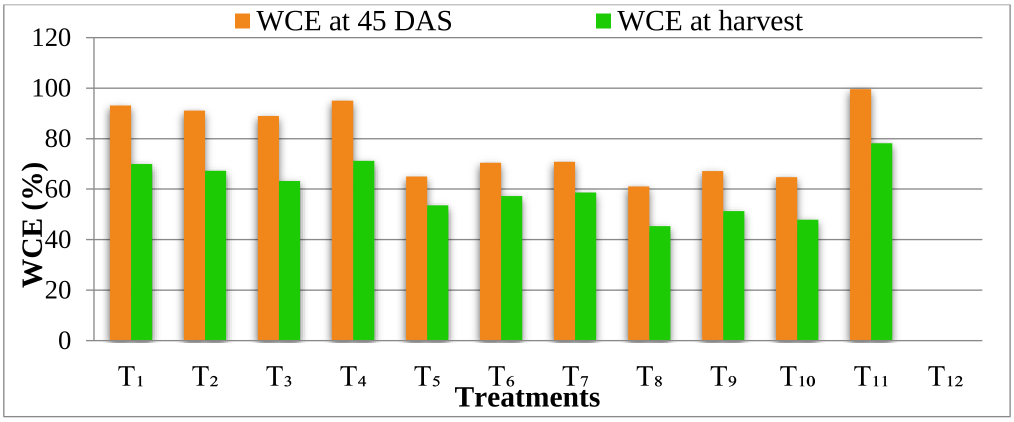

Fig 1. Weed control efficiency (WCE %) of direct seeded rice as influenced by weed management practices

Growth analysis

The growth analysis of the direct seeded rice reveals that the highest absolute growth rate and crop growth rate were recorded with hand weeding at 20 and 40 DAS followed by herbicide treatment, bispyribac sodium 10 SC 40 g a.i./ha as post emergence (Fig 2). Whereas, unweeded control has recorded lowest absolute growth rate and crop growth rate due to severe competition by weeds.

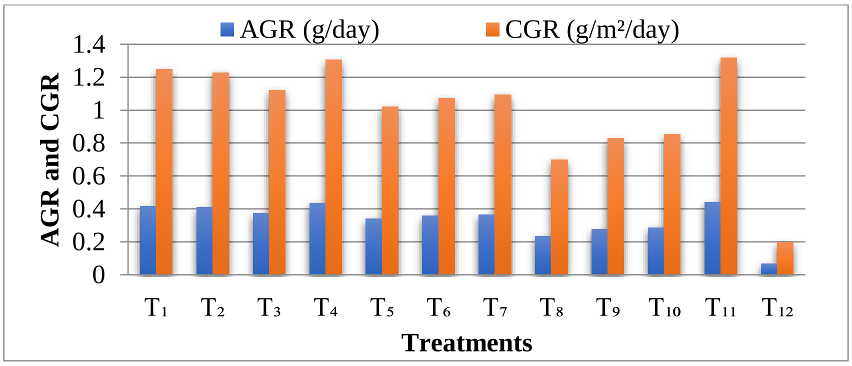

Fig 2. Absolute growth rate (AGR) and crop growth rate (CGR) of direct seeded rice as influenced by different weed management practices

Dry matter production and yield

The data pertaining to dry matter production, number of grains per panicle, grain and straw yield were presented in Table 3. Among the herbicide treatments, dry matter production and number of grains per panicle were significantly higher in bispyribac sodium and bensulfuron methyl + pretilachlor treatments. Grain yield is influenced by dry matter accumulation in different plant parts especially in reproductive parts and yield components. With increase in dry matter, the crop growth as well as yield attributes increases resulting in higher crop yields and there is strong positive correlation between dry matter production and grain yield (Fig 3).

The grain and straw yield recorded with bispyribac sodium 10 SC 40 g a.i./ha as post emergence (4987 and 6844 kg/ha, respectively) and bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i./ha as pre-emergence (4866 and 6716 kg/ha, respectively) were significantly superior to all other treatments and were on par with hand weeding at 20 and 40 DAS which recorded highest grain yield of direct seeded rice (5139 and 6970 kg/ha, respectively). Lowest grain and straw yield were recorded with unweeded control due to heavy weed infestation, which exploited the growth resources and resulted in poor growth of direct seeded rice. The results are on parity with the findings of Prakash *et al*. (2017) and Yogananda *et al*. (2017). The performance of allelochemicals was poor when compared with the synthetic herbicides, however, all the allelochemical treatments recorded significantly higher yield when compared with unweeded control and among them *Eucalyptus* leaf extract performance was relatively good.

The yield of a crop can be correlated with the weed density (Fig 4). Weed density has a negative correlation with grain yield of direct seeded rice indicating that, lower weed density is necessary for attaining higher grain yields.

Table 3. Dry matter production, No. of grains per panicle, grain and straw yield of direct seeded rice as influenced by different weed management practices

Treatments	Dry matter production (g/hill)	No. of grains per panicle	Grain yield (kg/ha)	Stalk yield (kg/ha)
T_1	19.93	61.87	4866	6716
T_2	19.51	61.43	4751	6592
T_3	18.41	60.55	4526	6513
T_4	20.35	64.42	4987	6844
T_5	15.58	51.01	3817	5910
T_6	16.53	51.23	3871	5851
T_7	17.94	61.08	4216	5998
T_8	12.93	48.58	2141	4128
T_9	15.19	46.73	3484	5350
T_{10}	14.96	48.04	2832	4478
T_{11}	20.92	66.06	5139	6960
T_{12}	6.80	49.82	688	1485
C.D (p=0.05)	1.76	4.91	347	358

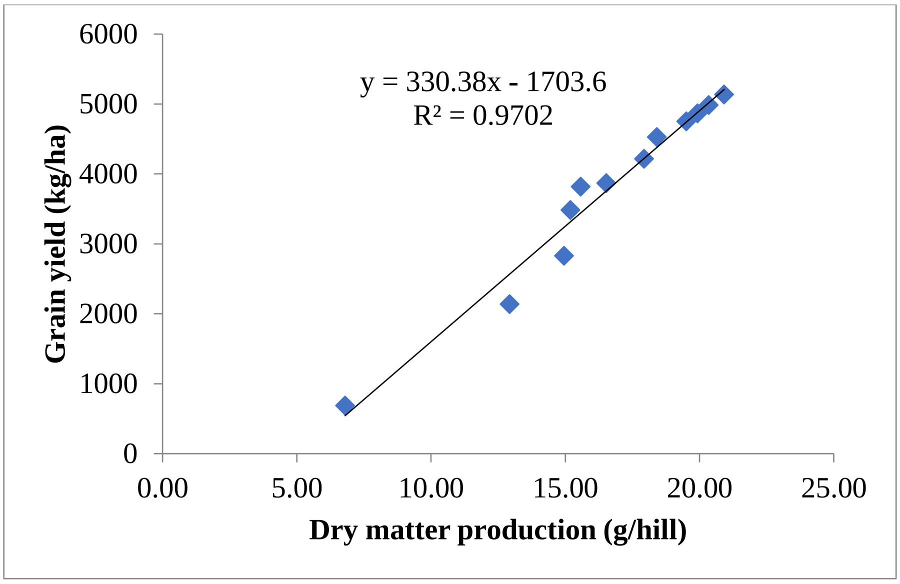

Fig 3. Correlation between dry matter production and grain yield of direct seeded rice

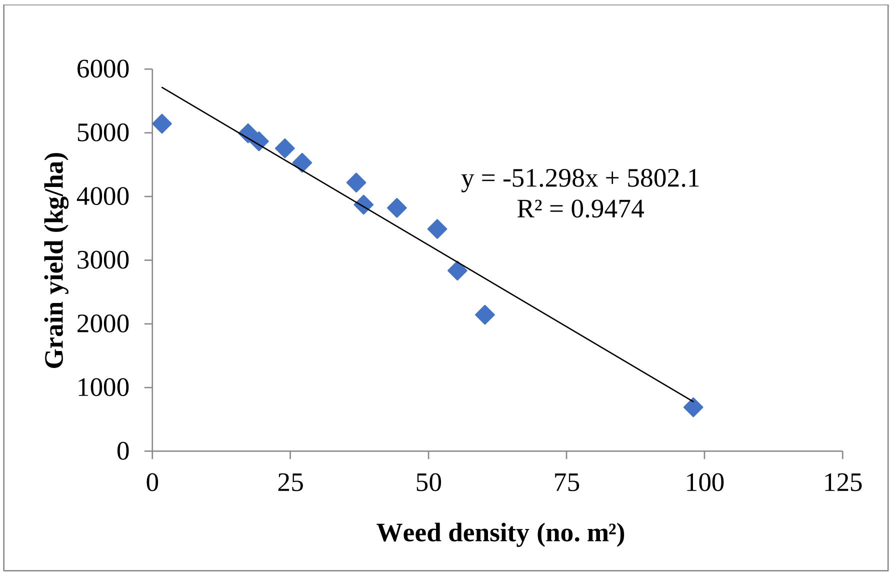

Fig 4. Correlation between weed density and grain yield of direct seeded rice

Conclusion:

Pyrazosulfuron resistant *Echinochloa colona* and *Eleusine indica*, can be best controlled by using herbicides, quizalofop-p-ethyl, cyhalofop-p-butyl, metamifop (grass killers) and bispyribac sodium. But, when the overall weed scenario is considered, application of bispyribac sodium 10 SC 40 g a.i./ha as post emergence or bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i./ha as pre-emergence were reported to give higher growth parameters and grain yield of direct seeded rice along with reducing the infestation of herbicide resistant weeds. Among aqueous allelochemical extracts, *Eucalyptus* leaf extract was remarkably better and can be used as weed management strategy under organic weed management during labour scarcity.

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RECENT ADVANCES IN WEED MANAGEMENT THROUGH HERBAL HERBICIDE

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Abstract

Weeds cause higher crop losses than any other crop pests, although they are underestimated in tropical agriculture. Controlling composite weed cultures in the agricultural field is tough. Many synthetic herbicides have been used in weed management practices during last 50 years. Initiatives are being made to reduce the strong dependence on synthetic herbicides, which may negatively impact on human health and the environment. Natural/herbal products, including essential oils, plant extracts, allelochemicals, and agricultural byproducts, are gaining popularity as an alternative to synthetic herbicides since they are harmless due to their short environmental half-lives and low toxicity. Since they strongly emphasize environmental conservation, practical viability, compatibility with integrated programs, and ecological stability, these natural/herbal herbicides are excellent substitutes for synthetic herbicides, particularly in organic agriculture. Herbal herbicides appear to be useful for weed control in sustainable agriculture. These herbal herbicides, in judicious combination with other weed management practices, would be a potential tool for combating weed problems in agriculture.

Keywords: Crop loss, herbal products, essential oils, plant extracts, allelochemicals, agricultural byproducts, weed management.

Introduction

One of the most challenging pests to control in crop production is weed. If left unchecked, weeds can negatively influence agricultural productivity and quality by competing with crop plants for nutrients, water, and light. Weeds can reduce agricultural output by 34% on average (Oerke, 2006). Weed control is generally achieved by cultural, mechanical, chemical, and biological methods. Chemical weed management has been one of the most used techniques during the past 50 years. Synthetic herbicides appear to be a simple and affordable way to eliminate weeds. Still, their extensive and indiscriminate use has potential ability to pollute soil and groundwater, increase the amount of harmful residue in agricultural products, raise weed herbicide resistance, and might harm human and animal health (Duary, 2008; Jabran *et al.,* 2015). According to several studies, synthetic herbicides may result in health issues, including cancer, birth deformities, and nerve damage (Naik and Prasad, 2006). Furthermore, the residue left behind by synthetic herbicides may damage crops cultivated in rotation and non-target plants.

Many producers are looking at new, non-chemical weed management techniques and switching to organic agriculture due to ecological, environmental, and health issues brought on by the extensive use of herbicides (Duke *et al.,* 2002). A sustainable strategy for protecting our environment would be replacing synthetic herbicides with naturally occurring chemicals with herbicidal potential. Using natural materials such as essential oils, agricultural byproducts, plant extracts and allelochemicals is said to be more eco- friendly than chemical herbicides. These organic compounds never lead to environmental poisoning since they disintegrate quickly in the

environment, do not stay in the soil for a longer period and do not enter the underground water (Rassaeifar *et al.*, 2013). An effective weed control strategy may also involve the use of plant species that can produce and release phytotoxic allelochemicals. Several plant species, including mustard (Brassicaceae), cereal rye *(Secale cereale)*, sunflower *(Helianthus annuus)*, Sesame (*Sesamum indicum*), amla (*Emblica officinalis Gaaertn*), ice-cream bean [*Inga dulcis* (Roxb.) Willd], Devil's tree [*Alstonia scholaris*) R. Br.], Jamun (*Syzygium cuminis*) have an adverse influence on other plant species (Duary, 2002; Dhima *et al.*, 2009; Mondal *et al.*, 2020). Allelopathy can be used in different ways to manage weeds. The first is to spread allelopathic plant leftovers as mulch or employ allelopathic cover crops in rotation. Using water extracts of allelopathic plants as herbicides is another promising technique to employ allelopathy to manage weeds (Dhima *et al.*, 2009). Several studies have shown the application of allelopathic plant water extracts for weed control (Dhima *et al.*, 2009; Jamil *et al.*, 2009). The application of allelopathic plants/crops with considerable weed inhibitory properties, in combination with common weed management strategies, might play an important role in the development of sustainable agriculture. There are very few approved herbicides for weed control in high-value crops, such as vegetables, and consumers are more interested in organic products. Therefore, today's agriculture needs a modified weed management system to deal with the problems associated with the use of synthetic herbicides. We present a brief overview of the natural solutions that are now available on the market and their usage as an alternative approach for weed management below, keeping these issues in mind.

Concept of Herbal Herbicide

There are several plants in and around our surroundings. Some of them have allelopathic effects. Still, several plants are not grazed, browsed, nibbled, or otherwise enjoyed by herbivores or are invaded by insects and infected with pathogens. Some of these plants have medicinal/aromatic, cosmetic, preservative, repellant, antibiotic, empirical remedial, nutraceutical, and other properties. Entire or parts of certain plants possess herbicidal and other properties. Such plants exude active chemicals (Mandal *et al.*, 2002) into the environment by exudation, leaching, or decomposition or excrete attractants (water/alcohol soluble compounds) that inhibit germination and establishment of almost all types of annual weeds in anaerobic and aerobic soils. These bioactive molecules/phytochemicals or extracts of plant origin having herbicidal properties are called herbal herbicides or Phyto herbicides.

Types of herbal herbicides

Herbal products can be used as weed-controlling agents in four forms as a plant extracts, essential oils, allelochemicals, and natural byproducts. These four plant products have been used as potential herbal herbicides for decades. In herbal herbicides primary mode of action is the inhibition of weed germination and the reduction of plant growth. Plant extract from any part of the plant contains many constituents, such as extracted peptides and secondary metabolites, such as alkaloids, terpenoids, tetraterpenoids, and so on.

From plant-extract

Plant extracts, which have traditionally been used for medical or nutritional purposes, could be used to create herbal herbicides for sustainable agricultural practices in weed management. Extracts from many plant parts, such as leaves, stems, roots, and seeds, have the potential to be utilized as natural herbicides. Some plants can inhibit the germination and development of other plants by releasing phytotoxic allelochemicals, which are metabolites such as alcohols, fatty acids, phenolics, flavonoids, terpenoids, and steroids. These allelochemicals are released by

Plant species	Source	Phytotoxic effects	Target weed	Reference
Aglaia odorata Lour.	Leaf extract	Inhibit growth and development	*Echinochloa crus-galli, Lolium perenne*	Kato-Noguchi *et al.*(2016)
Ammi visnaga Lam.	Plant extract	Inhibit seed germination and seedling growth, photosynthesis, cell division, and cell death and induce membrane destabilization	*Lolium. multiflorum, Echinochloa crus-galli, Digitaria sanguinalis, Setaria italica*	Travaini *et al.*(2016)
Matricaria chamomilla	Plant extract	Suppressed seedling and germination growth	*Phaseolus vulgaris*	Kadioglu *et al*,(2005)
Ailanthus altissima (Mill.) Swingle	Leaf extract	Inhibit germination and growth	*Medicago sativa*	Tsao *et al.*(2002)
Juglans nigra	Plant extract	Pre- and post-emergent and inhibit the growth	*Conyza canadensis*(L) *Cronquist., Conyza bonariensis*(L) *Cronquist*	Shrestha (2009)
Oryza sativa	Hull extracts	Inhibit germination, seedling growth	*Echinochloacrus-galli*	Ahn *et al.*(2000)

volatilization, leaching, or decomposition (Putnam and Duke, 1974; Cheema and Khaliq, 2000). Allelochemicals can reduce weed growth by inhibiting photosynthesis, decreasing chlorophyll content, disrupting cell membranes, and inhibiting enzyme activity (Ghanizadeh *et al.*, 2014). Many plants may have allelopathic potential and have been utilized for weed control in both laboratory and field investigations. There are around 400,000 chemicals in plants having allelopathic action, of which only 3% have been discovered for herbicidal activity (Einhellig and Leather, 1988). The remaining substances are unknown, although they might contain effective growth inhibitors.

Cynara cardunculus phenolic extract has phytotoxic effects due to the presence of an aromatic ring in its composition, which consists number of hydroxyl group (Ben Kabb *et al.*, 2020). These phytotoxic qualities damage the plasma membrane, contributing tooxidative stress and most basic effects. Phytotoxic water extracts of *Sorghum bicolor* are well-known examples of Herbal herbicides that may reduce weeds without reducing yield (Dayan *et al.*, 2009)

. The use of sorghum water extract reduced the biomass of *Echinochloa crus-galli*by 40%, resulting in an 18% improvement in rice production (Weston *et al.*, 2013). In another situation, extracts from the leaves, stem, flower, and root of *Brassica nigra*K. Koch was shown to substantially inhibit *Avena fatua*germination, growth, and radicle length (Tsiamis *et al.*, 2016).

The inhibitory impact is mostly caused by high amounts of glucosinolates, the bitter sulfur-containing chemicals found in large quantities in *Brassica sp*. These substances can be hydrolyzed to isothiocyanates, thiocyanates, and nitriles, resulting in new biologically active particles with the

potential to decrease weeds. When isothiocyanates interacted with cell-damaging sulfhydryl-containing enzymes, they inhibited the germination of *Matricaria inodora, crus-galli, Sonchus asper, Amaranthus hybridus, and Alopecurus myosuroides Huds*. (Tsiamis *et al.,* 2016), in addition toplaying role as an inhibitor to many fungi and pathogenic and food spoilage bacteria. Other plants having phytotoxic compounds include *Pisum sativum* against the germination, growth, and development of *Polygonum persicaria, Amaranthus hybridus, Galinsoga parviflora Cav.,*

Chenopodium album, and *Medicago sativa* against the germination of *Artemisia vulgaris,* with up to 83% effectiveness in petri dish assays and up to 89% under field circumstances (Travaini *et al.,* 2016).

From essential oils

Plant essential oils have exhibited high phytotoxicity against many weeds and are a natural alternative to non-selective synthetic herbicides. Essential oils are volatile substances generally believed to be the products of distillation or steam stripping. They include natural tastes and scents that produce distinctive smells (Mukhopadhyay, 2000), as well as allelochemicals that inhibit seed germination and plant growth and can therefore be utilized as a weed control technique (Hazrati *et al.,* 2017). Moreover, they degrade quickly in the environment, making them suitable for weed management for organic farmers. Terpenoids, specifically monoterpenes and sesquiterpenes, are the primary constituents of essential oils and are frequently responsible for their plant inhibitory activity (Weston and Duke, 2003). The inhibitory effect against seeds or plants varies according to the species from which the essential oil is derived (Dudai *et al.,* 1999).

Aromatic plants have a high concentration of essential oils, and since these oils have an allelopathic impact, they can be utilized to suppress weeds in agro ecosystems. The essential oils of some aromatic herbs, such as Oregano, Sweet marjoram *(Origanum majorana*), and lemon basil (*Ocimum citriodorum*), were shown to inhibit the germination of Palmer amaranth (*Amaranthus palmeri*) (Dudai *et al.,* 1999). The germination of amaranth, purslane, and knapweed (Acroptilon repens) was significantly inhibited by the essential oils from Lawson cypress (*Chamaecyparis lawsoniana*), rosemary, white cedar (*Thuja occidentalis*), and Eucalyptus. It suggests that these plants can be used as a natural pre-emergence herbicide to control weeds (Ramezani *et al.,* 2008). The herbicidal action of volatile oils from Eucalyptus citriodora against Congress grass was reported by (Singh *et al.,* in 2005). The herbicidal efficacy of volatile oils from *Eucalyptus citriodora* against various agricultural weeds, such as little seed canary grass *(Phalaris minor*), common lambsquarter, barnyard grass, chickweed (*Ageratum conyzoides*), congress grass, and *Amaranthus spp.,* was also observed in laboratory research (Batish *et al.,* 2005). These volatile oils have similar effects to glyphosate in terms of their action.

The use of essential oils appears promising for weed control. They might be utilized as natural herbicides for weed management in organic agriculture, but their efficacy is only temporary since they are particularly sensitive to photolysis and volatilize fast. As a result, essential oils may be used with other weed management methods to provide broad-spectrum weed control.

Agricultural byproducts

Weed management with agricultural byproducts is an interesting and viable alternative to chemical herbicides. Corn gluten meal (CGM), Brassicaceae seed meals (BSMs), and soybean meal are examples of herbal weed management products (Dayan *et al*., 2009; Dayan and Duke, 2010). Corn gluten meal or corn grain protein, is a byproduct of wet milling maize kernels for usage in corn syrup and corn starch (Liu and Christians, 1997). The left-over substance possesses herbicidal

qualities that can inhibit seedling root growth and plant survival in germinating plants but does not inhibitroot growth in mature plants (Liu *et al.*, 1994).

Corn gluten meal was discovered and patented in the early 1990s as a natural pre-emergent herbicide for use in organic agriculture (Bingaman and Christians, 1995). Bingaman and Christians (1995) discovered that when CGM was applied to the soil surface at rates ranging from 300 to 1000g m^{-2},it reduced plant survival,shoot length, and root growth in common lambsquarters *(Chenopodium album),* curly dock *(Rumex crispus*), purslane *(Portulaca oleracea),* black nightshade *(Solanum nigrum),* creeping bentgrass *(Agrostis palus*), *Amaranthus retroflexus* L., and creeping bentgrass (*Agrostis).*As listed in Table 4, natural byproducts prevent weed seeds from sprouting and establishment of seedlings.

Table2.Herbal herbicides from Essential oiltheir respective target weeds and Modes of action

Plant Species	Herbicide source	Phytotoxic effects	Target weed	References
Leptospermum scoparium J.R.Forst. and G.Forst.	Essential oil	Post-emergent and control seed emergence	*Digitaria spp.*	Dayan *et al.*(2011).
Vetiver grass (Vetiveria zizanioides Lynn Nas*)*	Essential oil	Inhibit the seed germination	*Velvetleaf (Abutilon theophrasti),*giant ragweed *(Ambrosia trifida),* pitted morning glory *(Ipomea lacunosa) and* common lambsquarters	Mao *et al.*(2004).
*Eucalyptus citriodora*Hook.	Volatile oils (leaves)	Inhibit germination and seedling growth	*Parthenium hysterophorus*	Singh *et al.*(2005).
Ocimum basilicum, Salvia officinalis, and Thymbra spicata.	Essential oil (leaves and flower)	Phytotoxic to germination and plant growth	*Agrostemma githago, Cardaria draba Desv. Chenopodium album, Echinochloa. Crus-galli, Reseda lutea.*	Onen *et al.*(2002)
*Origanum syriacum, Micromeria fruitcosa*and *Cymbopogon citratus* DC.	Essential oil	Inhibit seed germination	*Triticum asteivum, Amaranthus palmeri* S.Watson,*Brassica nigra*	Dudai *et al.*(1999).

Allelochemicals

Allelochemicalsare natural herbicides that have various advantages over chemical herbicides. Chemical structures vary greatly, and some of them can be used as lead molecules in synthesis of herbicides. Some natural chemicals are water-soluble and non-halogenated molecules. They have short half-lives compared to synthetic herbicides and are regarded as eco- friendly (Dayan *et al.,* 2014), explored the ways of selecting sources of natural products as prospective herbicides: (i) collecting pure chemicals from other laboratories, (ii) employing previously unexploited biological material, and (iii) using ethnobotanical and chemical ecology data to pick the herbicidal material. Many herbicides have been developed from plant allelochemicals, including Cinmethylin, AAL toxins, Mesotrine, Artemisinin, Biolophos, Glufosinate, and Dicamba. After detailed testing, it became clear that plant phytotoxic extracts may be an important tool in integrated weed control (Xiao *et al.*, 2017). As listed in Table 3, several allelochemicals prevent weed seeds from sprouting and establishment of seedlings.

Conclusion

Weed-related crop losses are still highly prevalent and can place a heavy financial strain on farmers. At present, considering the laborer shortage and economical viability, herbicides are gaining popularity for weed management in India. However, it comes at a high cost in terms of environmental pollution, shift in weed flora, development of herbicide resistance and risks to human health. Therefore, proper attention must be placed on using non-chemical weed control techniques, starting with adjustments of crop cultivation system to biological techniques and attempting to create, identify, and employ herbal herbicides. The potential use of secondary plant products as natural or herbal herbicides has attracted scientific curiosity in the context of recent advances in plant biochemistry. These herbal herbicides might be employed as a part of an integrated weed management system to decrease the risk of herbicide resistance, boost crop output, and lower production rates. Future research should concentrate on identifying and isolating new compounds and developing herbal herbicides because there are currently few commercially available ones. This will enable herbal herbicides to gain popularity and be widely used eventually.

Table3.Allelochemicals from allelopathic plants inhibitory to seed germination and seedling growth of weeds

Allelopathic plants	Allelochemicals	Targeted weeds	References
Datura stramonium	Alkaloids	*Cenchrus ciliaris, Notonia wightii* Wight and Arn.	Lovett *et al.*(1987)
Artemisia annua	Artemisinin	*Amaranthus retroflexus, Ipomoea lacunoso, Protulac oleracea, Artemisia annua, Lemna minor, Pseudokirchneriella subcapitata*	El Bazaoui *et al.*(2011)
Eucalyptus sp.	Essential oils	*Echinochloa crus-galli, Cassia occidentals, Lolium rigidum Gaudin, Saxifraga aspera, Myrica inodora, Amaranthus hybridus.*	Topal *et al*,(2007)

Sorghum bicolor	Sorgoleone	*Phalaris minor*, *Coronopus didymus, Cyperus rotundus, Solanaum nigrum, Amaranthusretroflexus, Amaranthus atrtemisifolia, Cecropia obtusifolia*	Thi *et al.*(2015)
Brassica sp. Raphanus sativus	Glucosinolates, Isothiocyanates	*Amaranthus myosuroides, Capsella bursapastoris, Convolvulus arvensis, Cuscuta spp., Daucus carota, Hirschfeldia incana, Sisymbrium polyceratium*	Soltys *et al.* (2013)
Piper longum	Serpentine	*Ehinochloa crus-galli, Amaranthus retroflexus, Digitaria sanguinalis, Leptochloa filiformis Lam., Taraxacum sp. Chenopodium album, Poa annua, Ipomoea purpurea, Sonchus arvensis, Rumex crispus*	Dayan *et al.* (2015)

Table 4. Herbal herbicides from natural products

By-product	Source	Targeted weeds
Distillers dried grains (DDGS)	Ethanol distillers	*Oxalis corniculata*, *Stellaria media.*
Corn gluten meal (CGM)	Wet-milling corn process	*Chenopodium album, Solanum nigrum*
Mustard seed meal	Mustard oil pressing	*Chenopodium album*

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PRESENT SCENARIO AND FUTURISTIC APPLICATION OF ARTIFICIAL INTELLIGENCE IN ANIMAL HUSBANDRY – AN OVERVIEW

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Abstract

Artificial Intelligence (AI) is one such technology which needs immediate implementation in the livestock industry. AI has emerged as a tool that empowers farmers in monitoring, forecasting, optimizing the farm animal growth, tackling parasites, biosecurity and diseases, monitoring farm animal along with farm management are some of the thrust areas in livestock industry where the use of AI technology can pay rich dividends. ArtificialIntelligence will help livestock farms accumulate and analyse data to accurately predict consumer behaviour, like buying patterns, leading trends, etc. With increased investments, farms will be enabled to automate processes, reduce major costs and improve the quality of livestock products like milk. Artificial Intelligence (AI) has developed as an interdisciplinary science based on computers and is concerned with building machines and equipment which use human intelligence to perform a particular task. AI has already made an immense contribution inveterinary and allied sciences by helping in devising various applications used in research and simulation aids. In addition, it has been put in to use efficiently in the field of veterinary sciences thereby hastening diagnosis, treatment, and prognosis of various animal diseases. Despite playing a vital role, AI has to be further refined in such a way to target the rural livestock farmers to improve animal health and production in developing countries that are in dire need of meeting food security requirements amidst the current scenario of population explosion.

Keywords: *Artificial Intelligence-Animal husbandry- Livestock-Animal Health*

Introduction

Artificial Intelligence is a form of computational science that involves the creation of machines that can replicate human thinking. Over the past decade, AI has become an indispensable part of Animal Husbandry and has made diagnosis cheaper, faster, and easier and helped to recognize patterns of medical and veterinary complications (Suresh *et al*., 2019). One of the key collaborations between artificial intelligence and medicine has been in the field of diagnostics. Where diagnosing an illness would take days, AI-programs can now diagnose diseases automatically through data analysis. As a result, diagnostics are much cheaper, faster, and easier. It is also being used in the form of clinical decision-making programs that recognize patterns of medical complications, and as information collection systems that hold extensive medical information of all past and present patients of a hospital. The information thus collected is also analysed by AI's to help create personalized medication (Ahuja,2019). AI-centric programs are also players in the field of drug discovery, as it can card through data that is too complex for humans. In similar ways, AI is also shaping itself to becoming an indelible part of the field of veterinary science. Artificial intelligence is a field of computer science dealing with the simulation of human intelligence through the use of computers.AI technology rapidly analyzes massive amounts of data according to a set of instructions known as algorithms to accomplish a specific task. Applying artificial intelligence to modern animal husbandry and aquaculture technology can intelligently identify animals of different weights and stages, feed differently, and improve the output rate of high-quality feeding

animals. With the huge growth in the world population, the farmers are transferring to smarter techniques that can aid in regulating the appropriate use of land, water, and energy to feed the planet and elude the global food disaster. Researchers believe that the answer lies in sensors, robots, and artificial intelligence. In cattle repeat breeders' problem is high and the reproductive efficiency is less than optimum (Kothandarman *et al.,* 2022).

The AI technology has been successfully adopted by several industries, and now it is set to revolutionize the future of farming with drones, robots, and intelligent monitoring systems. A technique for monitoring the health of farm animals and dairy cattle with a high degree of accuracy uses a camera and artificial intelligence (AI) to achieve a "smart" cow house. AI for detailed observation, powered image analysis could enable early detection of injuries and illnesses that could impact the quantity and quality of milk production. Various uses of AI include: 1. Artificial Intelligence in automated milking: Milk booth is a section of animal husbandry which has an increasing application of artificial intelligence system. With AI enabled smart sensors, the automated milking units can analyze the milk quality and flag for abnormalities in the product. 2. Precision livestock farming: Latest Dairy is implementing cow, milk and herd intelligence through their sensors and artificial intelligence technologies.

They offer sensors ranging from heat detection and calving to health monitoring sensors including the Sense Time Solution sensor, which detects and charts a cow's daily activities, such as ruminating, eating, and walking patterns. Today, there are numerous sensors available that can help farmers track alterations in animal movements, food intake, sleep cycles and even air quality in animal shelters. When paired with artificial intelligence software, this sensor provides users with early, proactive solutions to problems. Along with the capability to record information about reproduction, health and nutrition, the sensor also provides farmers with solutions for each individual cow. 3. Artificial Intelligence for health monitoring: The AI also sends alerts to the farmer about the change in the cow's behaviour allowing human intervention where needed. Without AI, it would be almost difficult for the farmer to keep a attentive eye on every cow in the herd. By using advanced AI and machine learning algorithms to predict deviations or abnormalities, farmers can now identify, predict, and prevent disease outbreaks, even before a large-scale outbreak. 4. Artificial Intelligence for Detection of Oestrus: The collar (with motion sensors) tied to on the cow neck for collects all types of data related to cow 24 hours a day. Artificial Intelligence components of the dairy automation system process the collected data to provide insights on the heat stress, change in feeding efficiency and the oestrus of the cow. The occurrence of oestrus cycle results in the release of special hormones that affect the cow's behaviour and movement. 5. Robotic System to Deliver Vaccines: For a sustainable economic future of dairy farms and to achieve 100 per cent compliance rate, modern dairy farms use a robotic injection system to deliver vaccines and reproductive medicines to domestic animals on the dairy farm.

The robotic system is incorporated with a dairy automation system, now a day. The robotic injection system reads the RFID tags attached to the cow's ear and gets health-related information and vaccination record for the cow. If the cow needs an injection, it is directed to the injection site and the injection mechanism position itself to deliver the medication in the cow's neck. 6. Artificial Intelligence in food supply chain: Blockchain can connect all aspects of the supply chain from producer to consumer and allow for food traceability and safety. From an agriculture and food perspective, proposing this type of evidence to consumers will become a competitive advantage and may not prove as challenging in dairy as in other areas of agriculture, such as beef, which exchanges ownership more frequently. 7. Artificial Intelligence in data collection: Previously,

collected data was generalized for an entire dairy farm. Through the use of sensors, AI and other technologies can provide individual data for each cow, allowing farmers to improve precision and accuracy when making managerial decisions (Salla Ruusuka *et al.*, 2016). 8. Artificial Intelligence in improvement of feed quality: With the use of robotics is quite efficient and speeds up harvesting time, when compared to traditional harvesting by hands. Moreover, the automated machinery indefinitely calculates moisture in the cereals harvest as well as overall yield. 9. Improving animal health using facial recognition systems: Several useful applications, such as helping us learn more about the animal's emotional and attentional state. For example, by studying the ear and eye movements of an animal, we can now understand its mood and excitement level with reasonable accuracy. It might help us regulate pain symptoms of animals. On further exploration, we may find injuries, diseases or even signal of predator attacks. 10. Gains in optimizing feed efficiency & energy intake: RGB-D camera can help farmers measure feed intake for individual cows and optimize feed expenses according to their animal needs. Technology can help us estimate performance of farm animals accurately. Their energy expenditure during lactation can be assesses based on parity, milk yield component, and body condition score.

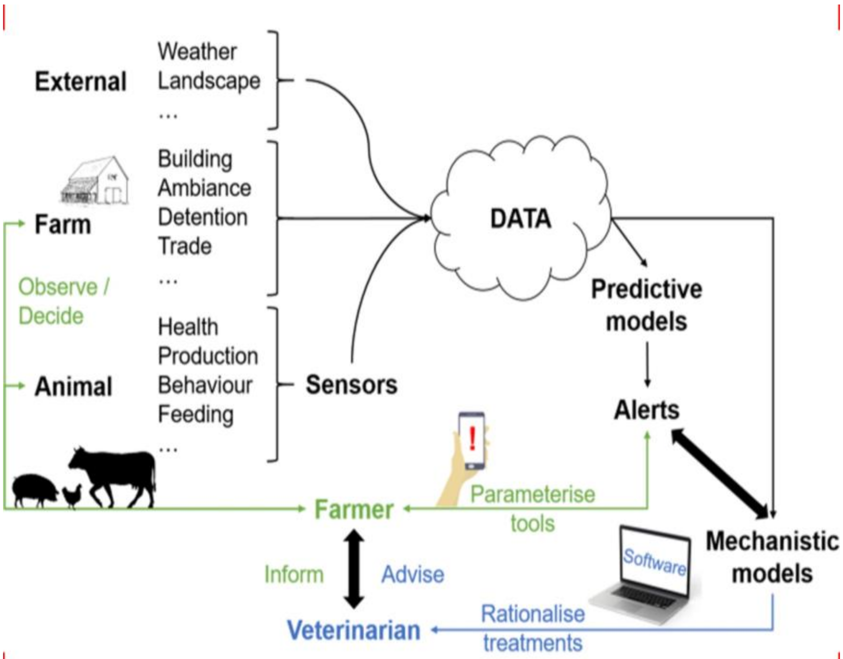

Figure 1 Representing Artificial Intelligence in Animal Husbandry

The day is not far when a drone will knock your door step to deliver milk with the desired fat and SNF percentage. The milk composition will exactly match as per your health requirement. Technology has redefined farming over the years and technological advances have affected the agriculture and livestock industry in more ways than one. Agriculture is the mainstay occupation in many countries worldwide and with rising population, which as per UN projections will increase from 7.5 billion to 9.7 billion in 2050, there will be more pressure on land as there will be only an extra 4% of land, which will come under cultivation by 2050. This means that farmers will have to do more with less. According to the same survey, the food production will have to increase by 60% to feed an additional two billion people. However, traditional methods are not enough to handle this huge demand. This is driving farmers and agro companies to find newer ways to increase production and reduce waste. As a result, Artificial Intelligence (AI) is steadily emerging a part of the agriculture industry's technological evolution. The challenge is to increase the global food

production by 50% by 2050 to feed an additional two billion people.AI-powered solutions will not only enable farmers to improve efficiencies but they will also improve quantity, quality and ensure faster go-to-market for crops and livestock products.

Basically, machines powered by Artificial Intelligence can not only act, but also understand and analyze. It has the potential to revolutionize human lifestyle. As a matter of fact, AI is still at a very nascent stage and the opportunities it could unravel, is still ambiguous. It is projected that eventually, AI will bring about qualitative progress and innovation, enhancing individual and societal well-being and the common good. Introduced in the 1950s, many AI methods have been developed or extended recently with the improvement of computer performance. Recent developments have been fueled by the interfaces created between AI and other disciplines, such as bio-medicine, as well as massive data from different fields, particularly those associated with healthcare. We are moving from the information era to artificial intelligence era. It is not data or information that will be used but the intelligence extracted from data to build solutions for the common citizens' use.

The strengths we have in India are that we have a vast IT talent pool, freedom from legacy assets, highest rate of data consumption and growth and rapid digitization across sectors. We need a significant focus to exploit this technology for disruptive growth to move from the existing economy to the new digital economy. Being one of the few global economies to have implemented and perfected automated AI processes across diverse sectors, India is leading in the AI usage trends.

Businessmen looking to invest in the Livestock industry have noted the increased spending power of the consumers and their willingness to pay a premium in order to have fresh and hygienic livestock products. As a result, it is expected that there will be investments made in this sector which will aid the introduction of technological advancements both in logistics and farm management. AI is one such technology which needs immediate implementation in the livestock industry (Baillie, 2007). AI will help livestock farms accumulate and analyze data to accurately predict consumer behavior, like buying patterns, leading trends, etc. With increased investments, farms will be enabled to automate processes, reduce major costs, and improve the quality of livestock products like milk. Artificial Intelligence, will be a disrupting inclusion into this industry (. Today local farmers and large dairy farms use fodder without much understanding of its impact on the milk. Changes in the fodder content and lifestyle of the animal, the weather and atmosphere, all of it have an impact on the production of milk and the quality as well. As Artificial intelligence and machine learning become more common and easily available, it is expected, that the use of such technology in the dairy industry will automate most of the farm processes while at the same time produce information based on the farm's operational history. Researchers believe that the future is in sensors, robots, and artificial intelligence (AI).

The AI technology has been successfully adopted by several industries, and now it is set to revolutionize the future of farming with drones, robots, and intelligent monitoring systems. A technique for monitoring the health of farm animals / dairy cattle with a high degree of accuracy uses a camera and artificial intelligence (AI) to achieve a "smart" cowhouse. Detailed observation by AI-powered image analysis could enable early detection of injuries and illnesses that could impact the quantity and quality of milk production. Have you ever thought how emerging technologies will affect agriculture in the long run to optimize management and profitability? We have seen the implementation of robotic milking machines, brushes for added cow comfort, and automatic calf feeders on dairy farms across the country and world. But, imagine a data system that monitors your cows' activities 24 hours a day, 7 days a week from lameness and estrous detection

to dry matter intake (DMI). With a new technology that recognizes each cow in the barn, this dairy farmer's dream becomes a reality.

In the recent times, with requirements of the better yield of farm animals, AI has emerged as a tool that empowers farmers in monitoring, forecasting, as well as optimizing the farm animal growth. Tackling parasites, biosecurity, and diseases, monitoring farm animal along with farm management are some of the thrust areas in livestock industry where the use of AI technology can pay rich dividends. There is a school of thought that associates AI with a dystopian future, where machines will take over or completely replace humans (Yongqiang et al., 2019). However, countering such theories, there are others who believe AI to be a revolutionary technology that has immense potential, if used vigilantly and appropriately. No doubt Artificial intelligence is the future.

Tab: 1 Farm animal related simulators

Bovine Breeder™ Artificial Inseminator Simulator	Helps students to visualize the interior of the female reproductive tract and in learning appropriate methods of cervix manipulation, artificial insemination, and pregnancy diagnosis
Bovine injection simulator	Teach all types of injections and infusions in different layers of skin and muscles
Bovine milking udder simulator	Teach proper udder care, milk diseases, and infection treatment and prevention. Also, teach proper California mastitis test performance and udder anatomy
Exercise physiology virtual lab	Supervise a clinical trial to investigate the acute and chronic physiological effects of high-intensity sprint interval training (SIT) on a sedentary lifestyle

Tab 2 List of data analysis software tools used in Animal Husbandry

Name of software	Veterinary medicine and clinical management software
IDEXX, cornerstone vet software (AAHA)	Health network, data backup, payment portal
AVImark, Henry Schein vet solution	Electronic medical records, patient reminders dental charts, support paperless practices
IntraVet	Clinical services
Vetter	Electronic vet record tool that allows you to see consolidated patient record
eVetPractice	Electronic medical records
DVMAX	Practice management
Hippo manager software	Clinical appointments, reminders, SMS
ezyVet	Next generation in cloud-based practice management software

Equine Gait trax / canine gait trax	Motion analysis software (2D and 3D)
DMAS-6 and DMAS-DV motion capture suits	Motion analysis software (2D and 3D)
EMPRES-i	Information system designed by FAO on global animal diseases
Winepiscope 2.0	Epidemiological veterinary medicine software
VETport	Cloud-based practice management software for veterinary clinics

Conclusion

Veterinary informatics can forge new possibilities within veterinary medicine and between veterinary medicine, human medicine, and One Health initiatives (Lustgarten et al., 2020). We can conclude that artificial intelligence allows easy data entry on farm records,monitoring farm activities, analysing economicperformance, improving animals' health improving soil richness. All these features and solutions endeavour towards '**smart farming**'. Artificial intelligence will use data toimprove the quality and clarity of decision making across all levels of the agricultural industry. Artificial intelligence has the potential to be better than humans at determining if individual animals meet market specifications through forecast of individual animal condition. However, as more farms get connected to technology, artificial intelligence and sensing technologies will start playing a more crucial role in helping farmers see patterns and solutions to tenacious problems in the modern animal farming.

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EFFECT OF LIQUID ORGANICS ON GERMINATION AND SEEDLING GROWTH OF MEXICAN ASTER (*Cosmos bipinnatus)*

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Abstract

Mexican aster or garden cosmos scientifically known as Cosmos bipinnatus is an attractive annual belongs to the family Asteraceae, native of Mexico, Central America. This species of cosmos is considered a half-hardy annual, although plants may re-appear via self-sowing for several years. It produces daisy-like flowers with shades of pink and purple as well as white. Among the various methods for inducing germination and seedling growth, seed treatment with panchagavya, vermiwash and humic acid play a significant role. Panchagavya *is also used as fertilizer and pesticide in agricultural operations. It is used as a foliar spray, soil application along with irrigation, as well as seed treatment. Vermiwash is an organic fertilizer obtained from units of vermiculture and vermicompost as drainage. It is used both as foliar spray and in the root zone of plant. It contains enzymes, secretions of earthworms which would stimulate the growth and yield of crops and even develop resistance in crops receiving this spray. Humic acid increases nutrient uptake, drought tolerance and seed germination. It increases the microbial activity in the soil, making it an excellent root stimulator. Humic acid increases the availability of nutrients in fertilizers and those already existing in the soil. With the above facts in mind, the present investigation was carried out to study the effect of different concentrations and soaking duration of liquid organics on germination and seedling growth of Mexican aster (Cosmos bipinnatus). The investigation was made in the Department of Horticulture, Faculty of Agriculture, and Annamalai University to find out the effect of liquid organics on germination and seedling growth of Mexican aster (Cosmos bipinnatus). The experiment was laid out in completely randomized block design (CRBD) with 13 treatments and 3 replications with humic acid @ 1 %, 1.5 %, 2 % for 24 hours soaking, vermiwash @ 10, 20 and 30 per cent for 5 hours of soaking, panchagavya @ 3 per cent for 1, 2 and 3 hours of soaking, water soaking for 8, 12, 16 hours and the control was maintained by the seeds without any treatment. Among the various treatments of Mexican aster seedling,* T_9 *– 3 % panchagavya @ 2 hours soaking hours soaking was found to be the best with 36.67 percentage of germination, 12.82 cm of shoot length, 2.06 cm of root length, 6.67 leaves per seedling and 1.08 g of seedling weight. This was followed by* T_5 *– 10 % vermiwash @ 5 hours soakings with the values of 35.25 %, 12.21 cm, 1.98 cm, 6.33 and 1.01 g of germination percentage, shoot length, root length, number of leaves per seedling and seedling weight respectively, while the minimum was recorded in the control -* T_1 *(14.67 %, 04.54 cm, 0.78 cm, 2.33 and 0.52 g respectively).*

Key words: *Mexican aster, Cosmos bipinnatus,* Panchagavya, *vermiwash, humic acid, germination, seedling growth*

Introduction

Cosmos bipinnatus, commonly known as garden cosmos or Mexican aster is an attractive annual belongs to the family Asteraceae, native of Mexico, Central America. This species of cosmos is considered a half-hardy annual, although plants may re-appear via self-sowing for several

years. It produces daisy-like flowers with shades of pink and purple as well as white. It is an ideal addition to flower beds, borders, and containers. It is perfect to make the edging. It attracts many butterflies including monarch, painted ladies add these beauties to the butterfly garden. Use cosmos plants as backdrops in mixed flower borders (Bijani *et al.*, 2021). Among the various methods for inducing germination and seedling growth, seed treatment with panchagavya, vermiwash and humic acid play a significant role. Panchagavya means "mixture of five products (cow dung, cow urine. milk, ghee and curd) of cow". Of these, the three direct constituents are cow dung, cow urine and milk and the two derived products are curd and ghee.

Panchagavya is also used as fertilizer and pesticide in agricultural operations. It is an organic product recommended for crop improvement in organic agriculture (Sangeetha and Thevananthan, 2010). It is used as a foliar spray, soil application along with irrigation, as well as seed treatment (Natarajan, 2002). Panchagavya has resulted in positive effect on growth and productivity of crops as reported by Somasundaram *et al.* (2007). Vermiwash is an organic fertilizer obtained from units of vermiculture and vermicompost as drainage. It is used both as foliar spray and in the root zone of plant. It contains enzymes, secretions of earthworms which would stimulate the growth and yield of crops and even develop resistance in crops receiving this spray (Atiyeh *et al*., 2002). It protects the environment from various chemical fertilizers. It is used as a liquid major nutritive and enzymatic element for promoting growth of all green plants. It extracted body fluid of earthworms is further nutrient rich with components promoting good plant-growth (Anand *et al*., 1995). Humic acid increases nutrient uptake, drought tolerance and seed germination. It increases the microbial activity in the soil, making it an excellent root stimulator. Humic acid increases the availability of nutrients in fertilizers and those already existing in the soil (Bashir Qadri *et al.,* 2016). With the above facts in mind, the present investigation was carried out to study the effect of different concentrations and soaking duration of liquid organics on germination and seedling growth of Mexican aster (*Cosmos bipinnatus).*

Materials and Methods

The experiment entitled "Effect of liquid organics on germination and seedling growth of Mexican aster (*Cosmos bipinnatus).*" was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University. The experiment was laid out in completely randomized block design (CRBD) with seven treatments and four replications. The cosmos seeds were obtained from the private vendor at Sivapuri village near Annamalainagar, Cuddalore district, Tamilnadu. The seeds are treated with panchagavya @ 3 per cent for 1, 2 and 3 hours soaking and vermiwash @ 10, 20 and 30 per cent for 5 hours soaking and the control was maintained by the seeds without any treatment. After the required period of soaking the seeds are taken out and transferred to the planting media. The media used in this study was red soil, sand and organic matter with the ratio of 1:1:1. The treatments were T_1 – Control, T_2 - Humic acid @ 0.5 % (24 hours soaking), T_3 - Humic acid @ 1.0 % (24 hours soaking), T_4 - Humic acid @ 1.5 % (24 hours soaking), T_5 - Vermiwash @ 10 % (5 hours soaking), T_6 - Vermiwash @ 20 % (5 hours soaking), T_7 - Vermiwash @ 30 % (5 hours soaking), T_8 - Panchagavya @ 3 % (1 hours soaking), T_9 - Panchagavya @ 3 % (2 hours soaking), T_{10} - Panchagavya @ 3 % (3 hours soaking), T_{11} - Water soaked (8 hours), T_{12} - Water soaked (12 hours), T_{13} – Water soaked (16 hours). Data on percentage of germination, shoot length, root length, number of leaves per seedling and seedling weight were recorded in all the treatments. The data generated were subjected to statistical analysis. The data were tested for their level of significance at P = 0.05 as per method of Panse and Sukhatme (1985).

Result and Discussion

The statistical analysis of data revealed that effect of different concentration of liquid organics on the germination and seedling growth of Mexican aster were significant (table 1). Among the various treatments of Mexican aster seedling, T_9 - Panchagavya @ 3 % (2 hours soaking) was found to be the best with 36.67 percentage of germination, 12.82 cm of shoot length, 2.06 cm of root length, 6.67 leaves per seedling and 1.08 g of seedling weight. This was followed by T_5 - Vermiwash @ 10 % (5 hours soaking) with the values of 35.25, 12.21 cm, 1.98 cm, 6.33 and 1.01 g of germination percentage, shoot length, root length, leaves per seedling and seedling weight respectively, while the minimum was recorded in the control (14.67 %, 04.54 cm, 0.78 cm, 2.33 and 0.52 g). This might be due to the presence of plant growth promoting substances produced by bacteria that are present in panchagavya (Naik and Sreenivasa, 2009). Microbes such as rhizobium, azotobacters, azospirillum, and phosphorus solubilizing bacteria, trichoderma and pseudomonas present in panchagavya act as liquid bio-fertilizer and bio-pesticides. Sometimes shoot length and root length were reduced with increasing concentration levels and duration with organic fortification which might be due to optimal dose of the organic product which is normally specific to crop (Sumangala and Patil, 2009). The results are in close conformity with the findings of Emily (2003) in *Withania somnifera* Dunal and Srimathi *et al*. (2013) in Jatropha and Pungamia.

It may be concluded from the result that, T_9 - Panchagavya @ 3 % (2 hours soaking) showed maximum germination percentage, shoot length, root length, number of leaves per seedling and seedling weight of Mexican aster.

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Table 1. Effect of liquid organics on germination and seedling growth of Mexican aster (*Cosmos bipinnatus*)

Treatments	Germination percentage	Shoot length (cm)	Root length (cm)	No. of leaves Seedling^{-1}	seedling weight (g)
T_1	14.67	04.54	0.78	2.33	0.52
T_2	27.33	09.65	1.42	4.33	0.77
T_3	28.50	10.07	1.58	4.66	0.82
T_4	30.67	10.44	1.69	5.25	0.88
T_5	35.25	12.21	1.98	6.33	1.01
T_6	33.33	11.72	1.84	6.25	0.95
T_7	19.50	07.08	1.17	3.33	0.61
T_8	21.25	07.64	1.21	3.50	0.65
T_9	36.67	12.82	2.06	6.67	1.08
T_{10}	23.33	08.23	1.29	3.67	0.68
T_{11}	32.00	10.94	1.78	5.66	0.92
T_{12}	25.33	08.92	1.37	4.00	0.72
T_{13}	17.67	06.34	1.05	2.67	0.57
SED	0.63	0.15	0.01	0.03	0.01
CD (P=0.05)	1.27	0.32	0.03	0.06	0.02

T_1 – Control, T_2 - Humic acid @ 0.5 % (24 hours soaking), T_3 - Humic acid @ 1.0 % (24 hours soaking), T_4 - Humic acid @ 1.5 % (24 hours soaking), T_5 - Vermiwash @ 10 % (5 hours soaking), T_6 - Vermiwash @ 20 % (5 hours soaking), T_7 - Vermiwash @ 30 % (5 hours soaking), T_8 - Panchagavya @ 3 % (1 hours soaking), T_9 - Panchagavya @ 3 % (2 hours soaking), T_{10} - Panchagavya @ 3 % (3 hours soaking), T_{11} - Water soaked (8 hours), T_{12} - Water soaked (12 hours), T_{13} – Water soaked (16 hours).

ENHANCING THE SHELF LIFE OF *Rhizobium* BIO INOCULANT BY DEVELOPMENT OF LIQUID FORMULATION

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Abstract

Liquid bioinoculant formulation has become the preferred technology to solve the problems associated with shorter shelf life, high contamination, poor quality, low fieldperformance and processing solid carrier in carrier based bioinoculant formulation. In the present study was conducted to formulate and determine the shelf-life of liquidbiofertilizer of efficient strain of Rhizobiumusing different cell protectants and nutrients in liquid broth. The cell protectants used were glycerol (10 mM), polyvinyl pyrrolidone (PVP, 2.0%), trehalose (10 mM). The treatments without addition of cell protectants (only broth) and carrier (lignite) based formulations were maintained as check. The formulated liquid biofertilizer of Rhizobium was stored in BOD incubator at 28±2 °C for a period of 6 months days and colony forming units were determined at monthly intervals. Liquid Rhizobiumbioinoculant formulated with trehalose (10mM) promoted long term survival of Rhizobiumfollowed byPVP (2%) and glycerol (10 mM) they supported 10^9 cells/ml up to 6 months of storage under ambient temperature (28°C to 32°C). The results of the present study clearly indicated that the liquid formulation of Rhizobiumcould be used more effectively than the carrier-basedformulation.

Introduction

Microbial inoculants represent an emerging technology designed to improve the productivity of Agricultural systems in the long run. They can be seen as a technology aligned with principles of sustainable agriculture, as opposed to the increased use of pesticides and fertilizers in recent times. *Rhizobium*is one of thepotential plant growth promoting rhizobacteria (PGPR). Its positive impacts on plant growth through several mechanisms which include enhancement of root development, production of growth regulators and nitrogen fixation. Plant growth promoting rhizobacteria (PGPR), such as *Rhizobium* inoculation in groundnut (a major oilseed crop) can boost crop growth and enhance yield in a sustainable manner. Further, *Rhizobium* has multifaceted advantages in crop nutrient uptake and soil quality improvement. *Rhizobium* forms nodule and fixes nitrogen biologically and thus, improve crop yield and soil quality. Chetti *et al*. (1995) found that highest growth parameters obtained from use of both *Rhizobium* and Phosphobacterium and that ultimately showed maximum dry matter accumulation in groundnut.FAO (1991) reported that most of the international producers of biofertilizers are engaged in the production of carrier-based inoculants. Peat is the most frequently used carrier for rhizobial inoculant industry because it has characteristics such as high water holding capacity and high surface area that support rhizobial growth and survival in large numbers. However, peat is not available in many countries, especially in tropics, and will be depleted in many areas in future (Smith, 1992).

The carrier based microbial inoculants produced in India aregenerally lignite, coal (or) Charcoal based. The major disadvantages associated with these carriers are shorter shelf life, poor-quality, high contamintion and unpredictable field performance.

The cost of solid carrier- based inoculant production is high as it is labour and energy intensive process, involving milling, sieving, and correcting P^H. Liquid inoculant

formulation is one solution to the problemsassociated with processing of solid carriers. The use of various brothcultures amended substance that promotes cells survival in thepackage and after application for seed (or) soil. Additives to liquidinoculant formulations should have a role in protecting microbialcells on seed at high temperature and during desiccation. Manykinds of polymers have been used for inoculant production becauseof their ability to limit heat transfer, their good rheological propertiesand high water activities (Mugnier and Jung, 1985). In the presentstudy, experiments were conducted to increase the survival of theliquid formulations of *Rhizobium*bioinoculant by theaddition of different polymers like polyvinyl pyrollidone (PVP), glycerol andtrehalose.

Materials and Methods

Microorganisms and Medium used

The strains used for liquid biofertilizer formulation was *Rhizobium* sp. (RZG-6) Yeast extract mannitol broth was used to culture *Rhizobium*. The sterilized broth wasinoculated with the Rhizobium strains and incubated at 28±2°C on a reciprocatory shaker for 24 hrs. The cell protectants *viz*., polyvinyl pyrollidone (PVP) 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5%, glycerol 5.0, 7.5, 10.0, 12.5, 15.0 and 17.5 mM, trehalose 1.0, 5.0, 10.0, 15.0, 20.0 and 25.0 mM, were added to one liter of Yeast extract mannitol broth during the preparation of media. The prepared media was inoculated with 1.0 ml log phase culture and incubated in BOD incubator at 28±2 °C.

Enumerating the viable cell population

The Yeast extract mannitol medium was prepared, sterilized, and plated in sterilePetriplates. The plates were kept at room temperature for 48h. Eight equal sectors on the outside bottom of the Petridishes wereradially marked. Four sectors were used for replication of one dilutionand four for another, allowing two dilutions per plate. Serial dilutionswere prepared by transfer of 1 ml each of inoculum into 9 ml sterilewater blanks to get 10^{-1} dilutions. Similarly, the dilutions were madeserially upto 10^{-10}. From the dilutions, 5 μl was pipetted out andplaced on the respective quadrant in the Petri plate. The plates wereincubated at 28 ± 2°C without any disturbance and individualcolonies were counted through this drop plate method (Somasegaran and Hoben,1994)

Effect of chemical amendments on shelf life of *Rhizobium* in liquid formulation

The Yeast extract mannitolbroth wasprepared with different chemical additives to increase the survival of cells in a liquid formulation. To test theefficacy of different concentrations of chemical amendments, *viz.*, polyvinyl pyrollidone (PVP), glycerol and trehalose were added to one liter of Yeast extract mannitolbroth separately. One ml of log phase culture of was inoculated individually in each broth. After attained the maximum cell population, 100 ml of each liquid formulation with different additives were transferred into sterile polypropylene bags, which were heat sealed. These liquid formulation and control werestored at room temperature (28 – 30°C) and survivability ofculture was determined at 30 days interval up to 180 days.

Results

To enhance the shelf life of *Rhizobium* cells in liquidbioinoculant, certain chemicals *viz*., PVP, glycerol andtrehalose were added as supplements to Yeast extract mannitolbroth and medium.

Results

To enhance the shelf life of *Rhizobium* cells in liquidbioinoculant, certain chemicals *viz*., PVP, glycerol andtrehalose were added as supplements to Yeast extract mannitolbroth and medium.

Survival of *Rhizobium* sp. (RZG-6) in different concentrations of PVP

The survival of *Rhizobium sp.* in liquid based formulation amended with different concentrations of PVP was studied up to 180 days and the results are given in (Table 14). It was found that 2.0 % (T_4) concentration favoured the population. In general, the population on 30th day were tends to be gradually decreased along with the storage period. The treatment T_4 recorded 42.00, 40.72, 36.62, 33.02, 29.67 and 13.14 × 10^9 CFU ml^{-1}on 30, 60, 90, 120, 150 and 180 days respectively. The treatment T_4 was followed by T_5 and T_3. The least counts were recorded in control (T_1).

Survival of *Rhizobium sp.* (RZG-6) in different concentrations of glycerol

The survival of RZG-6 was assessed in liquid based formulation amended with various concentrations of glycerol for a period of 180 days (Table 15). The treatment T_4 recorded maximum population of 37.00 × 10^9 CFU ml^{-1} followed by T_5. It was found that all the treatments were tends to be gradually decreasing with storage period.

Survival of *Rhizobium* sp. (RZG -6) in different concentrations of trehalose

The effect of various concentrations of trehalose in liquid formulation on the survival of *Rhizobium* sp.was assessed on 30 days interval basis up to 180 days (Table16). The results clearly indicated that amending trehalose in the growth medium (T_2 – T_8) supported the growth of *Rhizobium* sp. than control (T_1) treatment. Among the treatments, T_8 (30 mM) recorded least counts of 3.77× 10^9 CFU ml^{-1} at 180 days of storage.

Discussion

Effect of different concentrations of chemical amendments on the survival of *Rhizobium* sp. (RZG-6)

To increase the shelf life of *Rhizobium* cells in the liquid inoculant, certain additives *viz.*, trehalose was selected for further experiments of liquid based formuation of *Rhizobium* trehalose, polyvinyl pyrollidone (PVP), glycerol, at different concentration were added in the Yeast extract mannitol broth. Among the three additives, trehalose added broth maintained higher population of *Rhizobium sp* for entire storage period up to 180 days followed by PVP and glycerol. Trehalose (10mM) recorded higher population at 180th (46.32 × 10^9 CFU ml^{-1}) followed by PVP at 2% (42.00 × 10^9 CFU ml^{-1}) and glycerol at10mM (46.32 × 10^9 CFU ml^{-1}).

Trehalose is a puzzling compound which acts as a supplementary compatible solute; also, as reserve carbohydrate that may be mobilized during stress (Hounsa *et al.*, 1998). Trehalose is widely reported to enhance cell tolerance to desiccation and to osmotic and temperature stresses. It acts by stabilizing enzymes and cell membranes (Fillinger *et al.*, 2001). Torres *et al.* (2003) reported that trehalose at 1 per cent concentration protected *Candida* cells and showed viability of 72 per cent after 4 months storage. The possible effect of trehalose protective action is that it may be incorporated in to the cell or to induce the synthesis of metabolites that protect against stress (Gomez Zavaglia *et al.*, 2003). Kumaresan and Reetha (20011) reported that trehalose at 10mM concentration protected the cells of *Azospirillum* up to 10 months of storage.

Glycerol based media are not new as it has high water binding capacity and may protect cells from the effect of desiccation by slowing the drying rate (Manikandan *et al.*, 2010). Poonguzhali (2002) found higher survival of phosphobacteria in the medium and it might be attributed to the presence of glycerol.

In the present study, liquid formulations were better performed and they support higher survival population of *Rhizobium* cells for a longer period. Similar results were reported by Singleton *et al.* (2002). Liquid inoculants contain sufficient nutrients which permit the increase in population up to the level of one thousand million cells per ml, which results in three-to-four-fold increase in the numbers of viable bacteria compared to carrier based inoculants.

Singleton *et al.* (2002) developed liquid formulation of *Rhizobium* by adding various additives in the yeast extract mannitol media and claimed cell number of $1x10^{10}$ cells ml^{-1} in the liquid inoculant for the period of twelve months. Enhanced survival of *Rhizobium* cells in the liquid formulation may be due to the action of chemical amendments in the medium.

Thamizh Vendan and Thangaraju (2007) reported that liquid formulation of *Azospirillum* apparently had shelf life of 10 months compared to the carrier-based inoculant which had maximum of 6 months shelf life period. These results indicated that there is a substantial room to improve liquid inoculant formulation for *Rhizobium* sp. It has been demonstrated that the development of liquid formulation has several advantages including high cell count, zero contamination, longer shelf life, greater protection against environmental stresses and increase field efficacy.

Conclusion

Liquid bioinoculant formulation could be produced bysimple fermentation process with minimum labour, space and energy, as the culture from the fermentor is directly packed under asepticconditions and stored. The cost of production of liquid formulationcould be lesser than that of carrier formulation. From this study, ithas been concluded that liquid formulation of *Rhizobium*bioinoculant has a shelf life of more than six months compared to the carrierbased inoculant. Among the different chemical additives trehalose (10mM) performed well in liquid formulation of *Rhizobium*followed by PVP (2%) and glycerol (10mM).

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Table 1: Effect of different concentrations of polyvinyl pyrollidone (PVP) on the survival of *Rhizobium* sp. (RZG-6)

S. No.	Treatment	*Rhizobium* population (×10^9 CFU ml^{-1}) Period of storage in days					
		30	60	90	120	150	180
1	T_1–Control	21.34	5.96	0.72	0.016	0.0012	0.00024
2	T_2 -PVP (1.0%)	31.00	27.67	21.00	17.62	11.00	6.32
3	T_3 -PVP (1.5%)	36.12	33.02	29.14	26.56	23.32	14.00
4	T_4 -PVP (2.0%)	42.00	40.72	36.62	33.02	29.67	13.14
5	T_5 -PVP (2.5%)	38.13	35.12	30.62	27.33	23.62	10.00
6	T_6 -PVP (3.0%)	29.01`	23.14	23.25	15.17	7.08	5.52
7	T_7 -PVP (3.5%)	24.12	17.14	15.01	11.62	8.06	5.52
8	T_8 – PVP (4.0%)	23.34	20.24	16.34	14.46	11.12	6.0012
	SEd	1.16	1.39	1.40	1.31	1.26	0.57
	CD(=0.05)	2.32	2.78	2.8	2.64	2.52	1.14

Table 2: Effect of different concentration of glycerol on the survival of *Rhizobium* sp. (RZG-6)

S. No.	Treatment	*Rhizobium* population (×10^9 CFU ml^{-1})					
		Period of storage in days					
		30	60	90	120	150	180
1	T_1 – Control	21.34	5.96	0.72	0.016	0.0012	0.00024
2	T_2 - Glycerol (5.0 mM)	22.62	20.13	15.62	8.32	4.006	4.00016
3	T_3 - Glycerol (7.5 mM)	31.62	28.14	24.62	20.23	14.078	7.0005
4	T_4 - Glycerol (10.0 mM)	37.00	36.31	32.23	29.00	19.005	8.0006
5	T_5 - Glycerol (12.5 mM)	32.62	30.62	25.16	22.57	12.003	6.0004
6	T_6 - Glycerol (15.0 mM)	26.00	20.72	15.00	8.23	4.0026	1.0034
7	T_7 - Glycerol (17.5 mM)	23.62	19.47	14.12	7.62	3.0042	1.00072
8	T_8 – Glycerol (20.0 mM)	11.42	10.15	8.23	1.32	1.0034	1.00063
	SEd	0.99	1.27	1.26	1.31	0.86	0.39
	CD (=0.05)	1.98	1.26	2.52	2.28	1.72	0.78

Table 3: Effect of different concentration of trehalose on the survival of *Rhizobium* sp. (RZG-6)

S. No.	Treatments	*Rhizobium* population (×10^9 CFU ml^{-1})					
		Period of storage in days					
		30	60	90	120	150	180
1	T_1 -Control	21.34	5.96	0.72	0.016	0.0012	0.00024
2	T_2 – Trehalose (1.0 mM)	28.00	24.57	19.32	8.62	6.02	4.24
3	T_3 - Trehalose (5.0 mM)	34.43	30.63	27.31	19.01	11.00	9.02
4	T_4 - Trehalose (10 mM)	46.32	43.42	40.62	34.31	24.32	14.26
5	T_5 - Trehalose (15 mM)	38.14	34.23	29.62	23.14	12.62	7.06
6	T_6 – Trehalose (20 mM)	26.24	22.56	17.32	7.00	3.004	1.02
7	T_7 – Trehalose (25 mM)	25.42	19.62	14.02	4.32	2.06	1.008
8	T_8 – Trehalose (30 mM)	24.89	20.37	19.56	15.54	9.87	3.77
	SEd	1.04	1.39	1.47	1.41	0.97	0.06
	CD (=0.05)	2.08	2.78	2.94	2.82	1.94	0.12

IMPACT OF ORGANIC MANURES ON GROWTH AND YIELD PARAMETERS OF CAPSICUM (*Capsicum annuum L.*) UNDER PROTECTED CULTIVATION

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Abstract

A field experiment was conducted in the Sadayanchetti Palayam village, Sulur, Coimbatore district of Tamil Nadu during 2017-2019to study the impact of organic manure on yield of capsicum (Capsicum annuumL.) cv. Indra under protected cultivation. The experiment was laid out in randomized block design (RBD) with nine treatments and replicated thrice. The treatments include various sources of organic manure viz, farm yard manure and vermicompost, biostimulants viz. Humic acid, Chitosan, Sea weed extract and Effective microorganisms were given as foliar application on three stages viz., first spray on 2 leaves stage, second spray on 5-7 leaves stage and third spray on flowering. The various yield characters were recorded. The results of the experiment revealed that the yield parameters viz., number of flowers per plant, number of fruits per plant, single fruit weight and yield per plant were favorably influenced with application of RDF + Vermicompost + Sea weed extract.

Key words: *Organic manure, Biostimulants, Yield parameters, Capsicum, Foliar spray.*

Introduction

Vegetables provide nutritional richness, variety of taste, colour and texture to the diets. The capsicum is commercially high valued crop due to its high nutritional and medicinal properties. The capsicum fruit is rich in vitamin ‘C’ content which is about 118.6 mg/100 g. Other vitamins like vitamin ‘A’, ‘B6’, ‘B12’ and ‘E’ are also present. From every 100 g of edible portion of capsicum 24 k cal of energy, 1.3 g of protein, 4.3 of carbohydrate and 0.3 g of fat is provided (Anon, 1997), magnesium, calcium, potassium, phosphorus, and iron (Jadczak *et al.*, 2010). Capsicum has medicinal properties too such as antioxidant and antimicrobial properties; improves immune system, enhanced metabolism and even for cancer treatment.

India contributes one fourth of world production of capsicum it is extensively cultivated in hills of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir and Nilgiri during summer months. As an autumn crop, it extends up to winter months in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Bihar, West Bengal, and Madhya Pradesh. The total cultivable area under capsicum in India is 24,000 ha with an annual production of 3.26 lakh tones (NHB, 2018).

Organic management calls for use of organic supplements to supply the required macro, secondary and micro nutrients and to boost its immunity towards pests. A basket of choices are available to the producer, however they can be divided into two broad categories *viz.*, bulk and concentrated organic manures. Organic manures are usually applied basally i.e, incorporated into the media before planting. However, fermented organic liquid extracts are used in top dressing. The common organic sources available for crop are farm yard manure, vermicompost, sea weed extract, humic acid, chitosan, and effective micro-organisms.

Materials and Methods

The present investigation on “Impact of organic manure on yield of capsicum (*Capsicum annuum* L.) Under protected cultivation” have been taken in the SadayanchettiPalayam village, Sulur, Coimbatore district of Tamil Nadu, During 2017 to 2019. A field experiment was conducted to

study the impact of organic manure on yield parameters of capsicum (*Capsicum annuum* L.) under protected cultivation. The foliar application of biostimulants were applied on three stages, first spray on 2 leaves stage, second spray on 5-7 leaves stage and third spray on flowering stage. The experiment was laid out in randomized block design (RBD) with nine treatments (Table 1), replicated thrice.

Observations on growth and yield parameters *viz., plant* height, leaf area, number of flowers per plant, number of fruits per plant, single fruit weight and yield per plant. The observations collected during the experiment in respect of crop were statistically analysed using the procedure given by Panse and Sukhatme (1978). The IRRISTAT software was used for the statistical analysis of the data.

Table 1: Treatments adopted for the investigation

Treatments	
T_1	RDF + Vermicompost + Effective micro-organism
T_2	RDF + Vermicompost + Humic acid
T_3	RDF + Vermicompost + Sea weed extract
T_4	RDF + Vermicompost + Chitosan
T_5	RDF + Farm Yard Manure + Sea weed extract
T_6	RDF + Farm Yard Manure + Chitosan
T_7	RDF + Farm Yard Manure + Effective micro-organism
T_8	RDF + Farm Yard Manure + Humic acid
T_9	Recommended dose of fertilizer (RDF) 250:150:150kg NPK ha^{-1}

Result

Impact of organic manure significantly influenced the growth and yield parameters of capsicum (Table 2). The growth charactars *viz.,* plant height and leaf areawere significantly influenced by the different treatments. Amongthe various treatments tested, the treatment which received the application of RDF + Vermicompost + Sea weed extract (T_3) increased the plant height to 118.35 cm at final harvest and leaf area was 82.61 cm^2.Yield in general, is a highly complex parameter influenced by many factors of yield components and the goal of any crop management practice is to achieve increased production. In capsicum, number of fruits and single fruit weight are the most important traits in determining the yield and these parameters were greatly influenced by the application of biostimulants.

The highest flowers number (27.68), maximum number of fruits per plant (15.12), maximum single fruit weight (160.76 g) and highest fruit yield per plant (2424.38 g) was recorded in T_3 which was received the application of RDF + Vermicompost + Sea weed extract. The lowest flower count (27.21), number of fruits per plant (9.30), single fruit weight (118.79g) and fruit yield per plant (1097.92 g) was recorded in the treatment T_9 control.

Discussion

El-Bassiony *et al.,* (2010) reported vermicompost applied plots showed maximum increase in plant height, number of leaves, and number of buds. Further the superiority of vermicompost as stated by Shipitalo and Protz (1989), due to its structure which is similar to slow-release granule having organic matter core and clay casting they exhibit release of nutrients. It might be attributed

to the fact that application of vermicompost enhanced themicro-flora and enzymatic activity which might have augmented the plant growth and flowering. Maximum number of flowers enhanced more number of fruits per plant and increased the number of pickings (Chaitra and Patil, 2007 and Chamani, 2008).

Table 2: Mean Performance of growth and yield characters influenced by various treatments

Treatments	**Plant height (cm)**	**Leaf area (cm^2)**	**Number of flowers per plant**	**Number of fruits per plant**	**Single fruit weight (g)**	**Fruit yield per plant (g)**
T_1	99.24	69.61	26.22	11.03	131.04	1525.31
T_2	105.61	73.96	26.71	12.33	140.88	1823.98
T_3	118.35	82.61	27.68	15.12	160.76	2424.38
T_4	115.15	80.46	27.44	14.25	155.69	2272.89
T_5	102.41	71.89	26.48	11.69	136.05	1673.74
T_6	96.05	67.46	26.00	10.41	126.30	1374.80
T_7	108.78	76.11	26.95	12.96	145.84	1972.94
T_8	111.97	78.18	27.21	13.62	150.58	2122.57
T_9	89.83	64.71	24.76	9.30	118.79	1097.92
SED	**1.58**	**0.99**	**0.11**	**0.31**	**2.60**	**73.69**
CD(P=0.05)	**3.16**	**1.98**	**0.22**	**0.62**	**4.31**	**147.38**

Increased growth might be due to the presence of variety of major constituents in seaweed extract such as diverse plants nutrients, phytohormones or betains. The results of the present study agree with the findings of Alam *et al.* (2014) and Divya *et al.* (2015). In addition, sea weed extract contain macro and micro elements as well as growth promoting substances auxin and cytokinin, as these endogenous phytohormones are responsible for cell division, root and shoot elongation. Yield and yield attributes increased by sea weed extract may be due to the presence of plant growth regulators (indole 3 acetic acid, gibberellins, kinetin and zeatin). Similar findings reported by Saravanan*et al.* (2003) and Haider*et al.* (2012) in potato plants treated with lower concentration of sea weed extract showed higher growth and yield. Improvement in growth may be due to the presence of certain growth promoting constitution and osmoprotectant-betains in the extract.

In addition to reducing the cost of inorganic fertilizers, application of seaweed bio-stimulants enhances the yield and quality of produce in organic vegetables production thereby increasing the domestic and international market (Chatterjee and Thirumaran, 2014). Divya*et al.* (2015) found that sea weed extract increased production because the extract contains growth promoting hormones like cytokinins or gibberellins in addition to trace elements, vitamins, amino acids and antibiotics. Application of seaweed liquid extract stimulate different aspects of plant like good health, development of root system, absorption of mineral, enlargement of shoot, increased rate of photosynthesis and crop yield (Sridhar and Rengasamy, 2010).

Conclusion

Based on the present investigation, it can be concluded that application of RDF + Vermicompost + Sea weed extract can improve the yield attributing parameters which will ultimately results in increasing the productivity of capsicum and it could be recommended to the farmers for obtaining higher yield and monetary return.

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PATTERN OF CONSUMERISM AND ITS IMPACT OVER GREEN CONSUMERISM WITH REFERENCE TO BANGALORE CITY – AN EMPIRICAL OVERVIEW

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Abstract

This research paper is concentrating on pattern of Green Consumerism and articles referred till the year 2021. Observational research and Questionnaire helped in improvising the analysis of the study and outcome is change in the consumption pattern of family members in the comparison of decades; in the decade of 1990's people like to have food prepared at home and occasionally to have food with restaurants or other shops. This has made its drastic changes into the life of the same middle-class family to accept even restaurant food equally to prepared food at home in the decade of 2000. But now the interest of food processing industry and consumers are matching with health and wellness in the decade of 2010 & they are in the process of gaining health and wellness through change in food habits. A consumer's habit towards eco-friendly and non-conventional food consumption is called Green Consumerism. Consumerism is a result belief of happiness to large extent on the level of personal consumption. People change their belief over a period of time and advertisement influences a lot on this process.

"Being wealthier to consume" has become one of the habit of people and creation of debts, anxiety and waste are resulting the consumer to become greedier and lower psychological base in analyzing their purchases. This habit may lead unequal pattern of consumption for their income and expenditure. So, there is a requirement of ethical consumption. There is a change over in the income pattern and stress level of employees and unconditionally, everyone started accepting the food habits available as like think global and act global, due to increase in the availability of many food options and looking to have all the options avail in the market. This consumption pattern is getting changed in the market like to be restricted to the prepared food at home and now extending to the level of buying food available in the market. The main important point in this change over of consumption habit is both salary and anxiety levels are increasing into their work life as well as personal life.

Increasing the number of dual income middle class families are promoting a lot in thinking over the consumption of quality food and resulting in purchasing of organic or non-conventional food in Bengaluru city. There are two types of changes in food consumption habits; one is influence of urban life to the people who had shift from rural areas to Bengaluru and second one is people at Bengaluru, thinking about healthy food rather than fast food as it is urbanized culture. Here second one is most important shift in the pattern of green consumerism, because they tend to have healthy food and change their habit from unhealthy food habit culture.

At present, Internet aligned with traditional marketing approach is one of the better blends of strategy to attract a greater number of customers towards green food products. The customer's access to Internet in finding many food products as well other products may give the sense of customer's mindset as they are pleasant or unpleasant and through AI organic food may be promoted, then it will be one of the better opportunities to be created for Green Food Consumerism.

Key Words: *Green Consumerism, Changed food consumption habits, Strategies to Approach.*

Introduction

Consumerism is a belief of happiness to large extent on the level of personal consumption. People change their belief over a period and advertisement influences a lot on this process[1]. In metropolitan city like Bangalore, they found many changes in market places like, new markets, malls, fast food and fashion etc. as well as debt facilities providing to salaried and business people by many of the financial institutions like Credit Cards, EMI facilities, Advances from Banks, Personal Loans, etc. promotes customers' buying behaviour and resulting in change of Consumerism[1].

Review of Literature

Capitalistic nature of market condition is easily forming consumerism through various marketing strategies to attract consumers towards brands. Into the segment of food and other daily consumables, effective television ads and exhibitions are creating a pace for consumption habits[2]. Advertisements and other promotional tools are exploiting human values with the representation of commodities and giving more impact through quick change over of consumerism[2].

"Being wealthier to consume" has become one of the habit of people and creation of debts, anxiety and waste are resulting the consumer to become greedier and lower psychological base in analyzing their purchases. This habit may lead unequal pattern of consumption for their income and expenditure. So, there is a requirement of ethical consumption[2].

Consumption pattern of family members are getting changed in the comparison of decades; in the decade of 1990's people like to have food prepared at home and occasionally to have food with restaurants or other shops. This has made its drastic changes into the life of the same middle-class family to accept even restaurant food equally to prepared food at home in the decade of 2000. But now the interest of food processing industry and consumers are matching with health and wellness in the decade of 2010 & they are in the process of gaining health and wellness through change in food habits[3].

There is a change over in the income pattern and stress level of employees and unconditionally, everyone started accepting the food habits available as like think global and act global, due to increase in the availability of many food options and looking to have all the options avail in the market. This consumption pattern is getting changed in the market like to be restricted to the prepared food at home and now extending to the level of buying food available in the market. The main important point in this change over of consumption habit is both salary and anxiety levels are increasing into their work life as well as personal life[2].

In Bengaluru, we may find the environment created for shopping; industries providing better salary and correlation between these two are influencing a lot into spending habit. Ultimately this correlation has increased the level of inappropriate life style and now people are finding organic food consumption and health & wellness is another option to have their proper life style[2].

Increasing the number of dual income middle class families are promoting a lot in thinking over the consumption of quality food and resulting in purchasing of organic or non-conventional food in Bengaluru city[3].

There are two types of changes in food consumption habits; one is influence of urban life to the people who had shift from rural areas to Bengaluru and second one is people at Bengaluru, thinking about healthy food rather than fast food as it is urbanized culture. Here second one is most important shift in the pattern of green consumerism, because they tend to have healthy food and change their habit from unhealthy food habit culture[3].

Increase in the credit card usage among the consumers are influencing a lot of spending pattern and this also provides an accurate data on which commodity the consumer is spending, here an interesting fact that the spending on health & wellness and green food consumption is not getting decreased compared to other spending[3].

Many of the product's ads in the TV channels and other media, focusing more on single income households and making mother or wife as responsible for family health and husband is responsible for earning. Here in fact mother or wives have accepted that responsibility of their family health and looking forward into many organic food products availabilities in the market. Processed food consumption level also increased among middle class families due to dual income. The contribution of working women into the family expenditure is also supporting her in taking own decision into building better health habits in family members. Finally, the intention of mother or wife is to have quality work life which is more difficult to manage in the present inflation conditions[3].

Information and communication are increasing the role of purchasing more healthy products due to more work stress and anxiety in their work life. Here more important aspect is more people are getting habituated to Green Life Style in the food habits to avoid side effects of their work stress into their personal life; and, influential words of their peer group members are making their mindset ready to buy and consume healthy food. This new era of getting influence through peer group members or through friends' group in social media may give another dimension to the consumption of green food products in the society[3].

Stimulus – Organism – Response (SOR) framework of Ivan Pavlov is applicable to our study about the pattern of consumerism. Here Artificial Intelligence is focusing more onto the level of identifying the purchasing behavior and Behavioral pattern of Generation Z through various ways of social media; as they are getting more involved. Here it is possible to diagnose their psychological status, beliefs, preferences, economical background, etc. This is more important for influencing consumers through conditioned stimulus like various marketing approaches[4].

At present, Internet aligned with traditional marketing approach is one of the better blends of strategy to attract a greater number of customers towards green food products. The customer's access to Internet in finding many food products as well other products may give the sense of customer's mindset as they are pleasant or unpleasant and through AI organic food may be promoted, then it will be one of the better opportunities to be created for Green Food Consumerism[5].

As compared to Generation X and Generation Y, Gen Z are more time consuming in selection of food products, this has become an opportunity for many producers and services providers to promote more on the benefits of Green consumption habits[6].

It is so important to have pollution free environment, because of many consumers are getting more conscious over health and safety of their family as they are so excited to get more healthy food products even after spending more on non-conventional compared with conventional food[7].

Due to the consciousness of public towards food products, now-a-days pattern of Green Consumerism is reaching through growth and it is more important to provide a fixed platform from the end of the government to Green Food Products or Organic Food in the market to get associate with farmers, so it will be a standard in the market to cope with the desires of consumers to have healthy food[8].

Generation Z consumers are more focused on social media exposure for buying their products and services. The freedom for spending giving the wings to them in getting more attractive towards unhealthy food habits like junk foods. It is very essential to enlighten more knowledge on green consumerism and environmental protection[9].

Social media exposure to Generation Z consumers are more addicted and it is one of the opportunities to changing the Pattern of Green Consumerism through which the Green Marketing can be created and showcasing the benefits of green products and services may spread very fast through social media and may result into more consumption by Generation Z[10].

Consumers in Bangalore City are finding Eco Labeling for food products and which is more essential proof for them to believe on non-conventional or organic food product and a greater number of food products have to be supported by the government through Eco Labeling so, large number of products may create competitive market and finally food products with Eco Label will be avail at affordable price and helps a lot into reaching out a greater number of consumers[5].

Green Consumerism is shown more into upper middle-class segment and market is restricted for few people who are wealthy or middle-class segment with double income in their family. Indian consumers are not yet ready to accept Green Labeled products because of more price and not completely affordable as in their monthly groceries budget[6].

Customer satisfaction is more important related to their health and wellness through Green or Eco Labeled products, so it increases their perception level positively. Making Eco label mandatory may create awareness in making a greater number of changes in the production process of many products and helps to improve wellness of the people[7].

Standards set by the government bodies related to eco labels are helping a lot in improvising the quality of food processing industry[8].

Green Consumerism is like norms in the society with more amount of external force to have organic food, green life style, health and wellness, etc. and external force is through neighbors, media and government. Here this influence is supporting the thoughts of many consumers to have better food and healthy life; many brands are arising in the market to extend the view point of green consumerism[9].

It is very essential to promote green marketing by the companies to stimulate the consumers with green packaging, packing, etc. and this process may help to get support from Government also through CSR initiatives[10].

Green consumerism is one of the priorities to many organizations to satisfy not only government agencies but also society. Environment, Economic Considerations and Society are the triple bottom line need to be applied in their routine to get survival as well as profits in future[11].

Grey market in the market is ruling a lot in the place of Green products and it is very essential to monitor and take control over grey market and false products in the market[6].

Impact of green consumerism is more in the market as one of the physiological need to many consumers but they are getting more confused in selection of products because different products showcase their authenticity from different authorities[7].

Investment on Health and wellness is the trend at present in most of the middle age and elderly people in Bangalore city. Influence of change in the lifestyle due to more technological advancements in daily life as well as increase the level of stress among working people, is creating a major business platform for Green Food Products and people are ready to pay extra for these non conventional food for safeguarding their health[11].

Green Food or Non-conventional crop may help both farmer as well as consumer through maintenance of sustainable environment. This food consumption pattern may support in enhancing better health conditions of consumers[10].

Promoting Green Food production and selling not only into domestic market, export also may increase the interest level among farmers to increase their crop production with non-conventional approach. This may help in increasing the fertility level of farm land and quality food can be contributed to the nation[9].

Increase in the green eco labels are helping the consumers in buying Green food products and supporting their interest in consumption also. The community of health and wellness is ready to buy organic or non-conventional food and not ready to compromise at the price available. This fact may help any organization to take initiative towards production of eco label products[8].

Family concerns like maintenance of health of kids and age-old people may influence the buyer to take non-conventional food from market[9].

Eco labels knowledge with consumers are less and may be leading towards perception as available food products as Green. It is very essential to upgrade the promotion activities for Green or Eco Label products to create awareness among consumers. Consumer awareness is very important because people are more conscious about chemical free food need to be consumed for better health but, they are not aware of which one is chemical free[11].

Research Gaps

Environmental friendly food consumption is more consciously taken into consideration by many consumers in Bangalore City as a part of Health and Wellness and it is very important to understand at present because of more amount of expectation in the market and supply of green food products are less leading to imbalance of demand and supply and leads to increase in the prices. Now it is the time for bringing perfect competition for Green food products market and create healthy environment[10].

Hypotheses Development

H_0: Pattern of consumerism has no impact on green consumption.

H_1: Pattern of consumerism has an impact on green consumption.

Method of Questionnaire

This empirical study has observations of 93 customers and questionnaire is ranging from strongly disagree (1) to strongly agree (5). The responses are tested with the data collected from 93 participants accepted from Bangalore City. This survey is conducted in Bangalore city for 106 people where as amongst them 99 respondents given response and finally 93 respondents have given response completely and considered their response for the purpose of research. The external validity of the study is established based upon sample selected; age between 18 years to 50 years and content validity is considered based upon questions and observations. The reliability of data is difficult to prove completely in this qualitative measurement.

Representation of Data Collection

Correlation Analysis is the tool used for calculation to identify the influence of environment over consumers buying habits. The responses are tested with the data collected from 93 participants accepted from Bangalore City. This survey is conducted in Bangalore city for 106 people where as amongst them 99 respondents given response and finally 93 respondents have given response completely and considered their response for the purpose of research.

Health consciousness is preferred as significant response generated through group influence with 0.27, personal preferences with 0.36, price of products with 0.554, eco labels on products with 0.446, websites with 0.437, social media with 0.419 and influenced by marketing strategies are with 0.430.

This data clearly shows that both Health consciousness influenced by eco labels on products, personal preferences, group influence and marketing strategies and Environmental influence over green products consumption habits are there through; social media, websites, price of products.

Findings

- Sufficient options are available for consumers to have ready made foods as organic.
- Consumers are psychologically stronger to have healthy food, but they are not so confident that whether it is organic or non-organic.
- Economically middle-class consumers have the habit of eating healthy food as they are preparing food at home, compared to upper middle class and upper-class families.
- Internet marketing and traditional marketing, blend of both may reach a greater number of audiences to convert as green food consumers.
- Gen Z are more attractive towards fast foods and junk foods. It is the responsibility of green food producers to make green food as equally attractive. It is possible through social media.

Conclusion

Increase in the productivity through fertilizers and pesticides made all the farmers to get attract towards conventional farming method and now there is a requirement of non-conventional method of farming to fulfill the aspirations of many consumers those who are expecting Green Consumption. Usages of Natural fertilizers are more important in non-conventional farming method and with the help of natural fertilizers land fertility level also may get increase[9]. Indian consumers are more conscious about Green Consumerism into food products and they know the differences between Conventional and Non-conventional food ingredients. Green Consumerism knowledge level is more with rural consumers than urban consumers[10].

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STUDIES ON THE ROLE OF PGPR ON GROWTH AND YIELD ATTRIBUTES OF SUNFLOWER [*Helianthus annuus* L.] Var Co 1

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Abstract

Sunflower (Helianthus annuus L.) a new introduction to India in seventies, popularly known as "Surajmukhi" has become a familiar plant in India. It is an important oilseed crop for its premier oil and manifold uses of both industrial and pharmaceutical importance. Its cultivation has gained momentum due to its special features like short duration, photo-insensitivity, drought tolerance, adaptability to wide range of soil and climatic situations, lower seed rate, round the year cultivation, an ideal catch crop, high content of quality cooking oil and high seed multiplication ratio. The exponential growth of area under sunflower cultivation is an unparalleled example for any crop and this stands testimony for its suitability to fit to different cropping systems and patterns in the country (Kalloo, 2003).

Introduction

Sunflower oil contains zero transfats, which have been implicated in elevated cholesterol levels and increased risk of coronary heart disease. GJ seiler *et al.*, 2016).

PGPR have been applied to various crops that enhance the growth, seed emergence and crop yield and some have been commercialized (Minorsky, 2008). PGPR organisms like *Azospirillum, Azotobacter,* and *Paenibacillus* that have been shown to colonize the roots of various plants, and to increase the height, flower number, and total weight of sunflower plant (Minorsky, 2008).

Materials and Methods

The rhizosphere soil samples of tomato were used for isolation and enumeration of *Azospirillum, Azotobacter*, and *Paenibacillus* (phosphate solubilzing bacteria). Based on the efficiency of the plant growth promoting traits *A. lipoferum (SFAzs-05), Paenibacillus polymyxa (SFP-05) and Azotobacter chroococcum (SFAz-07)* and inoculant production.

Studies on the effect of inoculation of pgpr on plant growth and yield of sunflower in pot culture experiment

A pot culture experiment was conducted during Kharif (July- September, 2018) season in the pot culture yard of the Department of Agricultural Microbiology, Faculty of Agriculture, Annamalai University, Annamalai Nagar. The annual mean minimum and maximum temperature of the pot culture yard is 25° C and 39°C respectively and the mean highest and lowest relative humidity was 96 and 78 per cent respectively. The mean annual rainfall of this area is 1437 mm. The plant growth promoting rhizobacterial isolates A. lipoferum SFAzs-05, *A. chroococcum* SFAzs-07, *Paenibacillus polymyxa* SFP -05 were prepared with lignite + 1% of poly vinyl pyrollidone (PVP) as carrier based dual and consortium inoculants as used in this study.

Preparation of pots and seed inoculation

The cement pots of size 1'x 2'x 2' filled with garden land soil and sand in the ratio of 1:1. The seeds of sunflower Var. Co1 was surface sterilized with 80 per cent ethanol and 0.1 per cent mercuric chloride and washed the seeds with sterile distilled water for 3 to 4 times.

The seeds were mixed with carrier based rhizobacterial inoculants as single, dual and consortium of organisms separately having a cell load of $1x10^9$ cfu ml^{-1} and shade dried for 30 min. After shade drying, the seeds were sown at 25 seeds per pot. A control pot without inoculation was also maintained. The experiment was conducted in Completely Randomized Block Design (CRD) design with three replications. The treatments are as follows.

T_0 – Absolute control

T_1 -50% NPK

T_2 - 75% NPK

T_3 – 100 %NPK

T_4 - *A. lipoferum* SFAzs-05 + *Paenibacillus polymyxa* SFP -05

T_5 - *A. chroococcum* SFAzt-07 + *Paenibacillus polymyxa* SFP- 05

T_6 - *A. lipoferum* SFAzs-05 + *Paenibacillus polymyxa* SFP -05 + 75%NPK

T_7 - *A. chroococcum* SFAzt-07 + *Paenibacillus polymyxa* SFP- 10 + 75%NPK

Effect of plant growth promoting rhizobacteria isolates on the growth and yield attributes of sunflower Var.Co1 under pot condition

Plant height

Plant height was recorded from the ground level to the tip of terminal bud on 25, 45, 65 DAS and at harvest and expressed in cm.

Germination percentage

Germination percentage was computed by recording total number of sunflower plants germinated against number of seeds sown in each plot on seventh day after sowing.

Vigour Index

Vigour index was computed on 15 DAS using the following procedure suggested by Abdul Balli and Anderson (1973).

Vigour index = Germination percentage x Shoot length

Flower head diameter

The flower head diameter of sunflower capitula collected from the randomly selected sample plants was measured at harvest and expressed in cm.

Total number of seeds $head^{-1}$

The sample sunflower heads were dried, threshed and the number of filled and unfilled seeds were counted and recorded separately. The sum of both types of seeds was considered as total number of seeds $head^{-1}$.

Percentage of filled seeds $head^{-1}$

Percentage of filled seeds $head^{-1}$ was worked out by dividing the number of filled seeds $head^{-1}$ by the total number of seeds $head^{-1}$.

Results and discussion

Effect of plant growth promoting rhizobacterial (PGPR) inoculation on the growth and yield of sunflower in pot culture experiment

Sunflower (*Helianthus annuus* L.) is an important crop and ornamental plant in the world. It is easily cultivated and is grown mainly under rainfed conditions on a wide range of soils (Shehata and El- Khawas, 2003). It is used for animal feed and is the second most important crop producing

edible oil after soybean (Shehata and El- Khawas, 2003; Fairless, 2007). Recently, sunflower has also been cultivated to produce biodiesel (Demirbas, 2007).

Co-inoculants of microbes performed better than their individual inoculants. The combination of bacteria interacts with each other synergistically, provide nutrients, remove inhibitory substances and stimulate each other through physical and biochemical activities. Co-inoculation of PGPR with different beneficial properties may be the future trend for biofertilizer application to enable sustainable production (Han and Lee, 2005).

The relative increase in shoot and root dry weight due to AF-163 inoculation over reference strain was 41% and 45% respectively, and root dry matter was statically at par with un-inoculated positive control supplemented with full dose recommended nutrients Afshan Majeed *et al*., (2018).

Pot culture and field experiment to assess the effectiveness of PGPR consortium versus dual and single inoculant preparations on the growth of sunflower. Among the eight treatments tested, the consortium treatment of T_7 (*A. lipoferum* SFAzs-05 + *paenibacillus polymyxa* SFP-05 +75% NPK) showed maximum plant height (23.02 cm), germination percentage (92.05%), vigour index (1465.50), dry matter production (4778.29 kg ha^{-1}), Capitullum diameter (19.95 cm), number of seeds $capitullum^{-1}$ (980.12), number of filled seeds $capitullum^{-1}$ (899.02), seed filling percentage (90.96) and seed yield (1487.48 kg ha^{-1}).

The treatment T_7 was on par with T_4 (100% N PK). The minimum growth and seed yield was recorded in the treatment T_1 (Control). The biometric observations were the maximum in the treatment containing PGPR consortium followed by dual inoculation. The growth parameters and seed yield were maximum in the treatments containing bioinoculants when compared to chemical fertilizers. Previous studies indicates that the growth and yield attributes exhibited maximum values in treatments of bacteria inoculums and seedling treatments in combination with 75 per cent and 100 per cent nitrogen application (Hedge, 1998; Selvakumari *et al*., 2000).

Chandrasekar *et al*. (2005) reported that both morphological and yield parameters showed a better result through the combination of biofertilizers and chemical fertilizers than using either method alone. They also reported that the addition of *Azospirillum* with 100 per cent urea produced the highest yield compared with 100 per cent chemical fertilizer alone.

GehanMostafa and Abo – Baker (2010) studied the effect of biofertilizer and chemical fertilizers, separately and in different combinations, on the growth of sunflower (*Helianthus annuus* L.) to reduce the chemical fertilizers used, maximizing their use efficiency to obtain highest growth and productive parameters. The biofertilizers used as inoculums for seeds treatment of sunflower were *Azospirillum* and *paenibacillus polymyxa* and their mixture. Both bacterial inoculants and their mixture show an increase in growth parameters, nutrient content and yield when compared to the control. The result reveals that biofertilization treatments of *Azospirillum* + *Bacillus* plus 100 per cent chemical fertilizers produced the highest values in all growth and yield parameters compared with the control. The results also indicated that biofertilization, beside its ability to improve the nutrient supply in the soil, also increases the efficiency of added chemical fertilization.

TABLE: 1

Effect of plant growth promoting rhizobacterial (PGPR) inoculation of Plant height, Germination percentage and Vigour index of Sunflower var. Co 1

S. No	**Treatments**	**Plant Height (cm)**	**Germination (%)**	**Vigour Index**
1.	T_1 – Control	13.35	80.05	999.50
2.	T_2 -50% NPK	13.76	82.03	1152.50
3.	T_3-75% NPK	16.85	86.05	1010.50
4.	T_4 – 100NPK%	21.96	91.03	1460.10
5.	T_5 – *A. lipoferum SFAzs-05 + paenibacillus polymyxa SFP- 05*	15.97	83.04	1155.20
6.	T_6 – *A. chroococcum* SFAzt – 07 + *paenibacillus polymyxa* SFP- 05	17.45	87.04	1420.60
7.	T_7 - *A. lipoferum* SFAzs-05 + *paenibacillus* polymyxa SFP- 05 + 75% NPK	23.02	92.05	1465.50
8.	T_8 - *A. chroococcum* SFAzt – 07 + *paenibacillus* polymyxa SFP- 05 + 75%NPK	19.62	89.06	1425.30
SED		0.53	1.62	2.97
CD(P= 0.05)		1.06	3.52	5.95

The effect of PGPR inoculation on the plant height, germination percentage and vigour index of sunflower variety Co1 was measured and the results are furnished in Table: 1. Among the eight treatments tested, the maximum plant height, germination percentage and vigour index was recorded in the treatment T_7 (*A. lipoferum* SFAzs-05 + *Paenibacillus polymyxa* SFP-05 + 75% NPK) (123.02 cm), (92.05 %) and (1465.50) and the treatment T_7 was on par with T_4 (100% NPK) (17.45 cm), (91.03%) and (1460.10). Minimum plant height, germination percentage and vigour index were recorded in the treatment T_0 (Control) (13.35 cm), (80.05%) and (999.50). The plant height, germination percentage and vigour index were maximum in the treatment containing PGPR consortium followed by dual inoculation and chemical fertilizer.

Table: 2

Effect of plant growth promoting rhizobacterial (PGPR) inoculation on the Capitullam diameter, Number of seeds capitullam^{-1} and Number of filled Seeds capitullam^{-1} of Sunflower var. Co 1

S.No	Treatments	Capitullam diameter (cm)	Number of seeds capitullam^{-1}	Number of filled seeds capitullam^{-1}
1.	T_1 – Control	13.72	715.02	612.25
2.	T_2 -50% NPK	18.03	8720.25	620.00
3.	T_3-75% NPK	17.85	828.25	683.44
4.	T_4 – 100 %NPK	19.00	978.00	895.01
5.	T_5 – *A. lipoferum* SFAzs-05 + *paenibacillus polymyxa* SFP- 05	18.69	831.12	687.02
6.	T_6 – *A. chroococcum* SFAzt – 07 + *paenibacillus polymyxa* SFP- 05	17.02	952.45	856.05
7.	T_7 - *A. lipoferum* SFAzs-05 + *paenibacillus polymyxa* SFP- 05 + 75% NPK	19.95	980.12	899.02
8.	T_8 - *A. chroococcum* SFAzt – 07 + *paenibacillus polymyxa* SFP- 05 + 75%NPK	18.95	954.03	859.99
SEd		0.75	1.47	2.41
CD (P=0.05)		1.51	2.95	

Capitullum diameter

The effect of PGPR inoculation on the flower head diameter of sunflower var. Co1 was evaluated and the results are presented (Table: 2). Among the eight treatments tested, the maximum capitullum diameter was Recorded in the treatment T7 (*A. lipoferum* SFAzs-05 + *Paenibacillus* SFP-05 +75%NPK) (19.95 cm) and the treatment T_7 was on par with T_4 (100% NPK) (19.00 cm). The minimum capitullum diameter was observed in the treatment T_1 (Control) (13.72 cm). The capitullum diameter was the maximum in the treatments containing PGPR consortium followed by dual inoculation and chemical fertilizer.

Number of seeds capitullum^{-1}

The effect of PGPR inoculation on the number of seeds capitullum^{-1} of sunflower var. Co1 was evaluated and the results are presented in (Table 2)

Among the eight treatments tested on T_7 (*A. lipoferum* SFAzs-05 + *Paenibacillus polymyxa* SFP-05 +75%NPK) (980.12) showed the maximum number of seeds capitullum^{-1} and the treatment T_7 was on par with T_4 (100% NPK %) (978.00). The minimum number of seeds capitullum^{-1} was recorded in the treatment T_1 (Control) (715.02). The number of seeds capitullum^{-1}was the maximum in the treatments containing PGPR consortium followed by dual inoculation and chemical fertilizer.

Number of seeds capitullum^{-1}

The effect of PGPR inoculation on the number of seeds capitullum^{-1} of sunflower var. Co1 was evaluated and the results are presented in (Table 2).

Among the eight treatments tested on T_7 (*A. lipoferum* SFAzs-05 + *Paenibacillus polymyxa* SFP-05 +75%NPK) (980.12) showed the maximum number of seeds capitullum^{-1} and the treatment T_7 was on par with T_4 (100% NPK %) (978.00).The minimum number of seeds capitullum^{-1} was recorded in the treatment T_1 (Control) (715.02). The number of seeds capitullum^{-1}was the maximum in the treatments containing PGPR consortium followed by dual inoculation and chemical fertilizer.

Number of filled seeds capitullum^{-1}

The effect of PGPR inoculation on the number of filled seeds capitullum^{-1} of sunflower var. Co 1 was evaluated and the results are presented in (Table -2)

Among the eight treatments tested, on T7 (*A. lipoferum* SFAzs-05 + *Paenibacillus polymyxa* SFP-05 +75% NPK) (899.02) showed the maximum number of filled seeds capitullum^{-1}and the treatment T_7 was on par with T_4 (100% NPK) (895.01).The lowest number of filled seeds capitullum^{-1} was recorded in the treatment T_1 (Control) (612.25). The number of filled seeds capitullum^{-1} was the maximum in the treatments containing PGPR consortium followed by dual inoculation and chemical fertilizer.

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STUDIES ON THE EFFECT OF FOOD ADDITIVES, PACKAGING MATERIALS AND STORAGE CONDITION ON TOTAL CARBOHYDRATE OF TAMARIND PULP (CV. PKM 1) DURING STORAGE

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Abstract

Tamarind (Tamarindus indica L.) is an excellent multipurpose tree spice crop belonging to the family Caesalpinaceae. Pulp, Seed, and timber has enormous economic values as it is used in many household preparations and also in industrial uses. In this study tamarind pulp was obtained from tamarind trees cv. PKM 1 sprayed with potassium sulphate 1%. A total carbohydrate of tamarind pulp was analyzed over the period of six months of storage. The combined effect of food additives, packaging materials and storage condition also showed non significant influence on total carbohydrate content of tamarind pulp during storage period of the present study. However, among the different treatments studied, the treatment $A_4P_4S_2$ (pulp treated with gingelly oil @ 4.0 per cent packed in palmyrah leaf bag and stored under ambient condition) had registered higher total carbohydrate content values of 63.57 (M_1), 63.78 (M_3) and 63.87 (M_6) per cent and it was followed by $A_4P_3S_2$ (pulp treated with gingelly oil @ 4.0 per cent packed in mud pot and stored under ambient condition) which recorded total carbohydrate content values of 63.09 (M_1), 63.28 (M_3) and 63.63 per cent (M_6) in all the months of storage period. However, the lowest total carbohydrate content values of 60.25 (M_1), 60.36 (M_3) and 60.76 (M_6) per cent were observed with $A_5P_2S_1$ (pulp treated with sulphur fumes @ 0.2 per cent packed in aluminum foil and stored under refrigerated condition) over the period of storage.

Key Words: *Tamarind pulp, total carbohydrate, additives, packaging materials, storage Temperature*

Introduction

In India, recently, more emphasis and focus are being given on dry land horticulture, agroforestry and other afforestration programmes, since nearly 70 per cent of the arable land is under arid and semi arid regions. Most of these regions are subjected to the prevalence of recurrent droughts resulting in economic misery of the rural poor population. The Tamarind tree, *Tamarindus indica* L., one of the highly adapted valuable species for such wasteland situations, will go a long way in providing financial relief to such poor rural population for their livelihood. Tamarind is an important commercial tree spice of India and is a native of tropical Africa. Tamarind is valued mainly for its excellent pulp. Its acidic pulp is a favourite ingredient in many culinary preparations. The fruit pulp is the chief agent for souring curries, sauces, chutneys, and certain beverages throughout the greater part of India and some other parts of the world also. Tamarind has many consumer problems associated with quality parameters owing to high moisture level, seed, fibre, and rind contents. However, the qualities of the tamarind pulp stocks get deteriorated after one or two months of storage on account of faster discolouration and due to moisture at the time of packing. Quality deterioration is considered primarily due to poor postharvest management practices including processing (George and Rao, 1997). Since there is great scope for the export of tamarind from India, research on the post-harvest quality parameters (total carbohydrate) was studied in detail and protocol was standardized to process, pack, and store tamarind without deterioration in the quality and colour of the pulp. Only very meagre work has been taken up in

this aspect and scientifically documented. In addition to this, storage studies have been conducted only to the short period upto a maximum period of three months only, the periodical changes that take place during storage have not been assessed so far for a longer period. Keeping all these aspects in view, the present study on the tamarind quality, post harvest deterioration of pulp has been initiated with the following objectives.

- To study the influence of different postharvest chemicals (food additives) on total carbohydrate of tamarind pulp and to standardize suitable packaging and storage technologies for tamarind pulp

Materials and Methods

Effect of postharvest treatments on packing, storage, and quality (carbohydrate) of tamarind pulp

Postharvest study was conducted with the tamarind pods selected from the best treatment of the pre-harvest experiment I (Potassium sulphate 1% sprayed trees). From the selected pods harvested from the best treatment trees pulp was separated by cleaning and removing the shell, seed and fibre.

Experimental details

The experiment was laid out in a three factor completely randomized design and replicated twice. The observation on total carbohydrate was recorded in 1, 3 and 6 months after storage of tamarind pulp

Postharvest treatment details

$A_1P_1S_1$	Pulp treated with sodium chloride 4.0 per cent (common salt) packed in 300 gauge polyethylene bag and stored under refrigerated condition
$A_1P_2S_1$	Pulp treated with sodium chloride 4.0 per cent (common salt) packed in aluminium foil and stored under refrigerated condition
$A_1P_3S_1$	Pulp treated with sodium chloride 4.0 per cent (common salt) packed in mud pot and stored under refrigerated condition
$A_1P_4S_1$	Pulp treated with sodium chloride 4.0 per cent (common salt) packed in palmyrah leaf bag and stored under refrigerated condition
$A_2P_1S_1$	Pulp treated with ascorbic acid 2.0 per cent packed in 300-gauge polyethylene bag and stored under refrigerated condition
$A_2P_2S_1$	Pulp treated with ascorbic acid 2.0 per cent packed in aluminium foil and stored under ambient condition
$A_2P_3S_1$	Pulp treated with ascorbic acid 2.0 per cent packed in mud pot and stored under refrigerated condition
$A_2P_4S_1$	Pulp treated with ascorbic acid 2.0 per cent packed in palmyrah leaf bag and stored under refrigerated condition
$A_3P_1S_1$	Pulp treated with citric acid 4.0 per cent packed in 300 gauge polyethylene bag and stored under refrigerated condition
$A_3P_2S_1$	Pulp treated with citric acid 4.0 per cent packed in aluminium foil and stored under refrigerated condition

$A_3P_3S_1$	Pulp treated with citric acid 4.0 per cent packed in mud pot and stored under refrigerated condition
$A_3P_4S_1$	Pulp treated with citric acid 4.0 per cent packed in palmyrah leaf bag and stored under refrigerated condition
$A_4P_1S_1$	Pulp treated with gingelly oil 4.0 per cent packed in 300-gauge polyethylene bag and stored under refrigerated condition
$A_4P_2S_1$	Pulp treated with gingelly oil 4.0 per cent packed in aluminium foil and stored under refrigerated condition
$A_4P_3S_1$	Pulp treated with gingelly oil 4.0 per cent packed in mud pot and stored under refrigerated condition
$A_4P_4S_1$	Pulp treated with gingelly oil 4.0 per cent packed in palmyrah leaf bag and stored under refrigerated condition
$A_5P_1S_1$	Pulp treated with sulphur fumes (0.2 per cent) and packed in 300-gauge polyethylene bag and stored under refrigerated condition
$A_5P_2S_1$	Pulp treated with sulphur fumes (0.2 per cent) and packed in aluminium foil and stored under refrigerated condition
$A_5P_3S_1$	Pulp treated with sulphur fumes (0.2 per cent) and packed in mud pot and stored under refrigerated condition
$A_5P_4S_1$	Pulp treated with sulphur fumes (0.2 per cent) and packed in palmyrah leaf bag and stored under refrigerated condition
$A_1P_1S_2$	Pulp treated with sodium chloride 4.0 per cent (common salt) packed in 300 gauge polyethylene bag and stored under ambient condition
$A_1P_2S_2$	Pulp treated with sodium chloride 4.0 per cent (common salt) packed in aluminium foil and stored under ambient condition
$A_1P_3S_2$	Pulp treated with sodium chloride 4.0 per cent (common salt) packed in mud pot and stored under ambient condition
$A_1P_4S_2$	Pulp treated with sodium chloride 4.0 per cent (common salt) packed in palmyrah leaf bag and stored under ambient condition
$A_2P_1S_2$	Pulp treated with ascorbic acid 2.0 per cent packed in 300 gauge polyethylene bag and stored under ambient condition
$A_2P_2S_2$	Pulp treated with ascorbic acid 2.0 per cent packed in aluminium foil and stored under ambient condition
$A_2P_3S_2$	Pulp treated with ascorbic acid 2.0 per cent packed in mud pot and stored under ambient condition
$A_2P_4S_2$	Pulp treated with ascorbic acid 2.0 per cent packed in palmyrah leaf bag and stored under ambient condition
$A_3P_1S_2$	Pulp treated with citric acid 4.0 per cent packed in 300 gauge polyethylene bag and stored under ambient condition

$A_3P_2S_2$	Pulp treated with citric acid 4.0 per cent packed in aluminium foil and stored under ambient condition
$A_3P_3S_2$	Pulp treated with citric acid 4.0 per cent packed in mud pot and stored under ambient condition
$A_3P_4S_2$	Pulp treated with citric acid 4.0 per cent packed in palmyrah leaf bag and stored under ambient condition
$A_4P_1S_2$	Pulp treated with gingelly oil 4.0 per cent packed in 300-gauge polyethylene bag and stored under ambient condition
$A_4P_2S_1$	Pulp treated with gingelly oil 4.0 per cent packed in aluminium foil and stored under ambient condition
$A_4P_3S_2$	Pulp treated with gingelly oil 4.0 per cent packed in mud pot and stored under ambient condition
$A_4P_4S_2$	Pulp treated with gingelly oil 4.0 per cent packed in palmyrah leaf bag and stored under ambient condition
$A_5P_1S_2$	Pulp treated with sulphur fumes (0.2 per cent) and packed in 300-gauge polyethylene bag and stored under ambient condition
$A_5P_2S_2$	Pulp treated with sulphur fumes (0.2 per cent) and packed in aluminium foil and stored under ambient condition
$A_5P_3S_2$	Pulp treated with sulphur fumes (0.2 per cent) and packed in mud pot and stored under ambient condition
$A_5P_4S_2$	Pulp treated with sulphur fumes (0.2 per cent) and packed in palmyrah leaf bag and stored under ambient condition

Total carbohydrate

Total carbohydrate content of pulp was estimated by Somogyi (1952) and expressed in percentage. A sample of size 0.5mg was homogenised in hot 80 per cent ethanol. The residue was washed thoroughly till the washings failed to develop colour with anthrone reagent. The residue was extracted with 5.0ml of water and 6.5ml of 52 per cent perchloric acid at 0^oC for 20 minutes. The same process was repeated twice and the supernatant was pooled and made to 100ml. From this, 0.1 ml was pipetted and the volume was made up to 1 ml using distilled water, to which 4.0ml of anthrone reagent was added and heated for eight minutes. The solution was cooled rapidly and the intensity of green colour developed was read at 630nm. The standard curve was prepared using glucose. The glucose content in the sample was read from the standard curve and multiplied with a factor of 0.9 to obtain the total carbohydrate content.

Result and Discussion

Influence of additives, packaging materials and storage condition

The combined effect of food additives, packaging materials and storage condition also showed non significant influence on total carbohydrate content of tamarind pulp during storage period of the present study. However, among the different treatments studied, the treatment $A_4P_4S_2$ (pulp treated with gingelly oil @ 4.0 per cent packed in palmyrah leaf bag and stored under ambient condition) had registered higher total carbohydrate content values of 63.57 (M_1), 63.78 (M_3), 64.25 (M_5) and 63.87 (M_6) per cent and it was followed by $A_4P_3S_2$ (pulp treated with gingelly oil @ 4.0 per cent packed in mud pot and stored under ambient condition) which recorded total carbohydrate

content values of 63.09 (M_1), 63.28 (M_3), 63.74 (M_5) and 63.63 per cent (M_6) in all the six months of storage period. However, the lowest total carbohydrate content values of 60.25 (M_1), 60.36 (M_3), 60.67 (M_5) and 60.76 (M_6) per cent were observed with $A_5P_2S_1$ (pulp treated with sulphur fumes @ 0.2 per cent packed in aluminum foil and stored under refrigerated condition) over the period of storage.

Higher carbohydrate content of tamarind pulp during storage was observed by addition of sulphur / ascorbic acid packed in aluminium foil / polyethylene bag and stored under refrigerated condition. The results indicated that the additives sulphur fumes and ascorbic acid bring down the pH of the produce under low pH conditions physiological process (catabolic process) delayed. The packaging materials are impervious which prevents the gaseous exchange and low temperature storage inhibits the rate of respiration retard the catabolic process which results in breakdown of complex sugars. The sulphur and ascorbic acid as reducing agent, which retard the respiration rate, prevent the oxidation of carbohydrates results in high TSS and total sugar contents. The development of effective modified atmosphere storage conditions also slow down the rate of respiration would have inhibited the breakdown of carbohydrates resulted high TSS and total sugars. Under low pH most of the physiological activities are ceased that prevents the breakdown of carbohydrates into sugars, proteins and amino acids which are prime responsible for maillard reaction. Under effective modified atmosphere developed by the aluminium foil and polyethylene bag packing resulted in reduced oxygen and increase carbon di oxide level to the required level inhibits the respiratory rate. Under reduced rate of respiration, the catabolic process get slows down and conversions of starch (carbohydrates) into various simple sugars have been retarded thus resulted in slow rate of browning. Similarly, the low temperature storage also delays the browning reaction by inhibiting the rate of respiration. It was evident that these treatments registered high amount of carbohydrates whereas the high respiratory rate due to high temperature at ambient storage, porous nature of palmyrah leaf bag and mud pot increased the degradation of carbohydrate and converted into reducing sugars, protein and amino acid. Thus favored the higher rate of browning.

Table 35. Effect of food additives, packaging materials and storage condition on total carbohydrate (per cent) of tamarind pulp after one month of storage

		A_1	A_2	A_3	A_4	A_5	Mean
P_1	S_1	60.72	60.55	60.95	61.55	60.45	60.84
	S_2	60.82	61.33	61.55	61.90	60.82	61.28
	Mean	**60.77**	**60.94**	**61.25**	**61.73**	**60.64**	**61.06**
P_2	S_1	61.75	60.68	60.55	60.90	60.25	60.83
	S_2	60.72	60.92	61.03	61.70	60.75	61.02
	Mean	**61.24**	**60.80**	**60.79**	**61.30**	**60.50**	**60.93**
P_3	S_1	60.75	60.75	61.33	62.00	60.75	61.12
	S_2	62.75	60.65	60.77	63.09	60.65	61.58
	Mean	**61.75**	**60.70**	**61.05**	**62.55**	**60.70**	**61.35**
P_4	S_1	61.55	60.72	61.03	62.51	60.65	61.29
	S_2	63.02	61.07	62.55	63.57	60.83	62.21

	Mean	**62.29**	**60.90**	**61.79**	**63.04**	**60.74**	**61.75**
A×S	**S_1**	61.19	60.68	60.97	61.74	60.53	**61.02**
	S_2	61.83	60.99	61.48	62.57	60.76	**61.52**
	Mean	**61.51**	**60.83**	**61.22**	**62.15**	**60.64**	**61.27**

Initial value 60.25

	SED	CD (0.05)	
A	0.22071	0.44608	**
P	0.19741	0.39899	**
S	0.13959	0.28213	**
AP	0.44142	0.89217	NS
PS	0.27918	0.56426	NS
AS	0.31213	0.63086	NS
APS	0.62427	0.26172	NS

** - Significant at 1 per cent level A – Additives NS - Non significant
P – Packaging S - Storage

Table 35b. Effect of food additives, packaging materials and storage condition on total carbohydrate (per cent) of tamarind pulp after three months of storage

		A_1	**A_2**	**A_3**	**A_4**	**A_5**	**Mean**
P_1	**S_1**	60.89	61.08	61.18	61.97	60.45	61.11
	S_2	60.97	61.48	61.68	62.15	60.92	61.44
	Mean	**60.93**	**61.28**	**61.43**	**62.06**	**60.69**	**61.28**
P_2	**S_1**	61.90	60.79	60.67	61.10	60.36	60.96
	S_2	61.87	60.67	61.15	61.72	60.53	61.19
	Mean	**61.89**	**60.73**	**60.91**	**61.41**	**60.45**	**61.08**
P_3	**S_1**	60.93	60.90	61.49	62.21	60.87	61.28
	S_2	62.93	60.79	60.92	63.28	60.78	61.74
	Mean	**61.93**	**60.85**	**61.21**	**62.75**	**60.83**	**61.51**
P_4	**S_1**	61.70	60.89	61.21	62.65	60.78	61.45
	S_2	63.15	61.20	62.73	63.78	61.94	62.56
	Mean	**62.43**	**61.05**	**61.97**	**63.22**	**61.36**	**62.00**
A×S	**S_1**	61.36	60.92	61.14	61.98	60.62	**61.20**
	S_2	62.23	61.04	61.62	62.73	61.04	**61.73**
	Mean	**61.79**	**60.98**	**61.38**	**62.36**	**60.83**	**61.47**

	SED	CD(0.05)	
A	0.22126	0.44719	**
P	0.19790	0.39997	**
S	0.13993	0.28282	**
AP	0.44251	0.89437	NS
PS	0.27987	0.56565	NS
AS	0.31290	0.63242	NS
APS	0.62581	1.26483	NS

Table 35e. Effect of food additives, packaging materials and storage condition on total carbohydrate (per cent) of tamarind pulp after six months of storage

		A_1	A_2	A_3	A_4	A_5	Mean
P_1	S_1	62.38	61.10	61.56	62.31	60.93	61.66
	S_2	61.44	61.91	62.10	62.68	61.32	61.89
	Mean	**61.91**	**61.51**	**61.83**	**62.50**	**61.13**	**61.77**
P_2	S_1	62.45	61.22	61.10	61.58	60.76	61.42
	S_2	61.36	61.48	61.57	62.53	60.84	61.56
	Mean	**61.91**	**61.35**	**61.34**	**62.06**	**60.80**	**61.49**
P_3	S_1	61.40	61.32	61.93	62.78	61.28	61.74
	S_2	64.39	61.20	60.35	63.63	61.19	62.15
	Mean	**62.90**	**61.26**	**61.14**	**63.21**	**61.24**	**61.95**
P_4	S_1	62.27	61.34	61.66	63.20	61.19	61.93
	S_2	63.41	61.62	61.15	63.87	62.15	62.44
	Mean	**62.84**	**61.48**	**61.41**	**63.54**	**61.67**	**62.19**
A×S	S_1	62.13	61.25	61.56	62.47	61.04	**61.69**
	S_2	62.65	61.55	61.29	63.18	61.38	**62.01**
	Mean	**62.39**	**61.40**	**61.43**	**62.82**	**61.21**	**61.85**

	SED	CD(0.05)	
A	0.22237	0.44943	**
P	0.19889	0.40198	**
S	0.14064	0.28425	*
AP	0.44474	0.89886	NS
PS	0.28128	0.56849	NS
AS	0.31448	0.63559	NS
APS	0.62895	1.27119	**

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SCREENING OF OKRA HYBRIDS FOR YIELD, SHOOT AND FRUIT BORER, YELLOW VEIN MOSAIC VIRUS, OKRA ENATION LEAF CURL VIRUS AND POWDERY MILDEW DISEASE

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Abstract

Cultivation of okra in India is seriously affected by okra shoot and fruit borer (OSFB), yellow vein mosaic virus (YVMV), powdery mildew disease (PMD) and okra enation leaf curl virus (OELCV). Hence constant research is in progress to identify stable resistance sources against these pest and diseases. Screening of available genetic resources and incorporating the resistant genotypes in the crop improvement programme serves as a potential method in okra breeding for development of varieties/ hybrids. Therefore, in the present study using 19 hybrids and commercial check hybrid CO 4 was used to evaluate against OSFB infestation, PMD and OELCV under natural condition at orchard farm, Department of horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal. The data revealed that the incidence of YVMV was minimum (2.60 per cent) in OKHYB-4. The OSFB incidence (PDI) was lower in Anna-10 (9.11 per cent). There was no incidence of PMD and OELCV noticed in all the hybrids. Hence the okra hybrids viz. OKHYB-4 & Anna-10 can be recommended for commercial cultivation but tested for the location and season specific respectively before raising the commercial crop in the coastal region of Karaikal.

Key words *Resistance, Screening, OSFB, YVMY, OELCV, PMD*

Introduction

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop belonging to the family Malvaceae. Okra is grown throughout the tropical and subtropical regions of the world and in warmer parts of the temperate zone. India is the largest producer of okra globally, with a contribution of more than 72% (6 million tonnes) from an area of 0.5 million hectares (NHB, 2020). Okra has vast potential for earning foreign exchange as it has a significant share in fresh vegetable export (APEDA, 2020). Tender pods of okra are used as a delicious vegetable. It is used in canned, dehydrated, and frozen forms to a limited extent. Okra mucilage is used as a food, non-food, and medicinal product. Okra dry seeds are a rich source of oil (18-20%) and protein (20-23%). Hybrids that possess strong resistance to disease and pest and have better yielding capacity have become more popular among farmers as they ensure a high return on their inverstments. The introduction of a short inter-noded strong virus-resistant hybrid Radhika (15-20% more yield) by Advanta (2018) enhanced the popularity of hybrid okra across India.

The successful cultivation of okra is often hampered by an array of nearly 72 insect pests, of which shoot and fruit borer, *Earias vitella*; whitefly, *Bemisia tabaci*; aphid, *Aphis gossypii* and leafhopper, *Amrasca biguttula* are important (Dikshit *et al*., 2001). Yellow Vein Mosaic Virus (YVMV) is a devastating viral disease transmitted through white fly (*Bemisia tabaci*) in okra (Ali *et al*., 2000). YVMV belongs to the genus Begomo virus, family Geminiviridae. This viral disease causes colossal losses in the crop by affecting the quality and yield of the fruits. The identification of stable resistance sources is a continuous process to fight with this devastating menace. Among

the pests, Shoot and Fruit Borer (*Earias vittella*) is the most serious pest which causes direct damage to tender shoots and fruits. Currently, productivity of cultivated okra is gradually decreasing in the tropics due to infection by the begomovirus, okra enation leaf curl virus (OELCV) which have other hosts also grown in the region (Venkataravanappa *et al*., 2015). OELCV disease causes yield loss between 80 per cent and 90 per cent (Singh, 1996) and is widely emerging as an important threat to production and there is a need to evolve resistance against the causal virus.

Use of synthetic pesticides for managing pests and diseases is the immediate and most practiced method by the farmers but, okra being a vegetable with shorter harvesting intervals, poses residual hazards to the consumers. Therefore, emphasis is now been shifted in favour of host plant resistance, particularly insect and disease resistant/tolerant hybrids are more economical and environmentally safe. Hence, development of high yielding and tolerant/ resistant varieties or identifying good hybrids is the major necessity. However, frequent breakdown of resistance of most of the resistant varieties/ hybrids is a matter of concern and this needs continuous attention of the breeders. Therefore, there is an urgent need to develop okra hybrids which show resistance/ tolerance against these biotic stresses. Thus, in the present study, 19 hybrids of okra and one commercial check CO 4 was carried out to evaluate against OSFB infestation, infection of YVMV, PMD and OELCV under natural condition in the prevailing coastal climate of Karaikal. Keeping the above points in view, an experiment was conducted to screen the okra hybrids for pest and disease reaction and also suitability to coastal region of Karaikal giving high marketable fruit yield.

Materials and Methods

The study on screening of okra [*Abelmoschus esculentus* (L.) Moench] hybrids was carried out during kharif 2020 in the Horticultural farm at Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal. The field experiment using 19 hybrids of okra (Table 1) was laid out in a randomised block design with two replications during kharif 2020. The plants were spaced at 60 cm between row and 30 cm between plants in a row. The treatments were allotted at random and 48 plants each were maintained in a plot size of 10.5 m^2. The recommended horticultural practices and plant protection measures were followed uniformly. The estimated average yield hectare^{-1} was calculated based on the yield plant^{-1} and the average yield hectare^{-1} for each hybridswas worked out and expressed in tonnes.

The observations obtained were statistically analyzed for fruit weight, number of fruits plant^{-1}, yield hectare^{-1}, phenol content 90 days after sowing, incidence of shoot and fruit borer, and incidence of YVMV 90 days after sowing. The screening was done under normal epiphytic conditions adopting only need based plant protection measures. The crop was observed for the incidence of OSFB, YVMV, PMD and OELCV at 15 days interval commencing from 15 DAS to 90 DAS. The disease incidence was recorded on the basis of visual symptoms on the crop. All the 19 hybrids of okra were screened for incidence of pests and diseases under field conditions as per the procedures suggested for estimation of shoot and fruit borer incidence (*per cent*) (Table 2) it was calculated as per the procedure suggested by Rai and Satpathy (1998).

$$Per\ cent\ \text{fruit infestation} = \frac{\text{Total number of infested fruits}}{Total\ number\ of\ fruits} X100$$

Table 2 Grade for Shoot and fruit borer resistance (based on fruit damage)

Grade	Fruit infestation (%)	Rating scale
1	0%	Immune (I)
2	0.1% - 10%	Highly resistant (HR)
3	10.1% - 20%	Fairly resistant (FR)
4	20.1% - 30%	Tolerant (T)
5	30.1% - 40%	Susceptible (S)
6	40.1% and above	Highly susceptibility (HS)

The percentage of disease incidence (PDI) for the estimation of YVMV incidence (*per cent*) (Table 3) at different stages 15^{th} to 90^{th} day after sowing of okra was calculated as per the procedure suggested by Ali *et al.* (2005).

$$\text{YVMV incidence (\%)} = \frac{\text{Number of plants exhibiting YVMV symptom in each plottal number of infested fruits}}{Total\ number\ of\ plants\ in\ the\ same\ plot} X100$$

Table 3 Grade for classifying YVMV reaction of okra

Sl. No.	Rating scale	Severity Range (%)
1.	Immune (0)	0%
2.	Highly resistant (1)	1% - 10%
3.	Moderately resistant (2)	11% - 25%
4.	Tolerant (3)	26% - 50%
5.	Moderately susceptibility (4)	51% - 60%
6.	Susceptibility (5)	61% - 70%
7.	Highly susceptibility (6)	71% - 100%

For the estimation of powdery mildew incidence (*per cent*) (Table 4) at different stages 15^{th} to 90^{th} day after sowing of okra was calculated as per the procedure suggested by Elhassan *et al.* (2012).

$$\text{Powdery mildew incidence (\%)} = \frac{\text{Number of plants exhibiting PM in each plot}}{Total\ number\ of\ plants\ in\ the\ same\ plot} X100$$

Table 4 Grade for classifying powdery mildew reaction of okra

Disease Index (%)	Severity Grade	Symptoms	Remarks
75 - 100	1	Plant foliage covered with powder on the upper and lower leaf surfaces and leaf shedding.	Highly susceptible
50 - < 75	2	Plant foliage fully covered with powder.	Susceptible
25 - < 50	3	Plant foliage covered with powder.	Moderately Susceptible
1 - < 25	4	Few powder colonies appear on the lower surface of the leaf.	Low Susceptible
0	5	The leaves are completely free of powder colonies.	Resistant

The estimation of Okra Enation Leaf Curl Virus incidence (*per cent*) (Table 5) at different stages 15th to 90th day after sowing of okra was calculated as per the procedure suggested by Nazeer *et al.* (2014).

$$\text{OELCV incidence (\%)} = \frac{\text{Number of plants exhibiting OELCV}}{Total\ number\ of\ plants} X10$$

Table 5 Grade for classifying OELCV reaction of okra

Disease Index (%)	Severity Grade	Symptoms.	Remarks
0	0	No symptoms	Resistant
1 -20	1	Thickening of only secondary and tertiary veins.	Highly tolerant
21 - 30	2	Thickening of secondary and primary (mid-rib) veins.	Tolerant
31 - 50	3	Vein thickening, Leaf curling or Enation or both.	Susceptible
>50	4	Stunting along with vein thickening leaf curling or enation.	Highly susceptible

Result & Discussion

Mean performance serves as an important criterion in elimination the undesirable types in selection programme. In the present study, okra hybrids exhibited significant differences for all the characters for growth and yield thus offering scope for selecting the high yielding hybrids**.** The per cent infection and the hybrid reaction was assesed using the data recorded on the disease incidence and presented in the table 6.

In the present investigation based on the *per se* performance of nineteen hybrids, NBH-180-C recorded highest fruit yield plant^{-1} of 413.56 g (22.97 t ha^{-1}) with fairly resistance to OSFB and no incidence of PMD & OELCV. Yield is also influenced by individual fruit weight and it was

found maximum in Sumithra-15 (14.64 g) followed by OKHYB-6 (14.62 g), Green Gold (13.80 g) and Harsha (13.35 g). Earlier reports of Gangashetti *et al.* (2013) supported the present findings. About number of fruits plant^{-1} the hybrid NBH-180-C (33.07) recorded the maximum number of fruits plant^{-1} followed by OKHYB-6 (27.40). This was in accordance with the findings of Gangashetti *et al.* (2013) in okra.

Phenol content impact resistant against pest and disease incidence as under in the present investigation, it was observed significant differences among the hybrids for phenol content. The hybrid NBH-180-C (0.80 mg 100g^{-1}) (Table 6) recorded the maximum phenol content. Similar results have been reported earlier by Thalirkodi (2007). It was found that, among the YVMV incidence (Table 6) recorded hybrids, the lowest PDI for YVMV (90 days after sowing) was noticed in OKHYB-4 (2.60 *per cent*), Ajanta (3.94 per cent), OKHYB-2 (4.79 *per cent*) and Texico 55 (5.53 *per cent*) whereas all the other hybrids were free from YVMV incidence. Shoot and fruit borer incidence (Table 6) was lower in Anna-10 (9.11*per cent*) and higher in OKHYB-4 (21.31*per cent*). The hybrid Anna-10 was considered best based on their significant results over least incidence of shoot and fruit borer. Therefore, about incidence of pest and disease, hybrids with lowest incidence can be utilized for further commercial production and cultivation in the improvement of fruit yield coupled with its component traits. There is no incidence of Powdery mildew and OELCV in all the 19 hybrids.

The hybrid NBH-180-C recorded the highest fruit yield (22.97 t ha^{-1}) and the lowest was in Anna-10 (10.72 t ha^{-1}). The grand mean for this character was13.18 t ha^{-1} with a range of 10.72 to 22.97 (t ha^{-1}) (Table 6). However, all the 19 okra hybrids were tested for YVMV incidence during Kharif season 2020 (September) and the percentage of disease incidence has to be further test verified.

Conclusion

An experiment was laid for screening of okra hybrids for resistant to pest and diseases for the coastal region of karaikal, U.T of Pondicherry (INDIA). The results obtained by screening of 19 okra hybrids obtained from ICAR, SAUs, private seed companies for shoot and fruit borer (OSFB), yellow vein mosaic virus (YVMV), powdery mildew disease (PMD) and okra enation leaf curl virus (OELCV) revealed that the hybrid NBH-180-C recorded the highest fruit yield (22.97 t ha^{-1}), with lowest PDI of 12.38 % (fairly resistant).

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Table 1 Details of okra hybrids used for evaluation

Treatments	Hybrids	Source
T_1	Sumithra-2000	Suvarna Hybrid Seeds, Yelahanka, Bangalore, Karnataka.
T_2	Sumithra-15	Suvarna Hybrid Seeds, Yelahanka, Bangalore, Karnataka.
T_3	Anna-10	Suvarna Hybrid Seeds, Yelahanka, Bangalore, Karnataka.
T_4	Ajanta	Suvarna Hybrid Seeds, Yelahanka, Bangalore, Karnataka.
T_5	Ankur-2028	Ankur Seeds Private Limited, Nagpur, Maharastra.
T_6	Green Gold	Namdhari Seeds, Ramnagara, Bangalore, Karnataka.
T_7	Texico 55	Texcity Hybrid Seeds, Coimbatore, Tamil Nadu.
T_8	Saarika	Nunhems (Bayer), Medchal, Rangareddy, Telangana.
T_9	Harsha	Siva Sakthi Agro Hybrids, Attur, Salem, Tamil Nadu.
T_{10}	Mahy 28	Maharashtra Hybrid Seeds, Mumbai, Maharastra.
T_{11}	Garjana 550	East-West Seed International, Gangapur, Aurangabad.
T_{12}	CO4	TNAU, Coimbatore, Tamil Nadu.
T_{13}	NBH-180-C	ICAR-IIVR, Varanasi, Jakhini, Uttar Pradesh.
T_{14}	OKHYB-2	ICAR-IIVR, Varanasi, Jakhini, Uttar Pradesh.
T_{15}	OKHYB-3	ICAR-IIVR, Varanasi, Jakhini, Uttar Pradesh.
T_{16}	OKHYB-4	ICAR-IIVR, Varanasi, Jakhini, Uttar Pradesh.
T_{17}	OKHYB-5	ICAR-IIVR, Varanasi, Jakhini, Uttar Pradesh.
T_{18}	OKHYB-6	ICAR-IIVR, Varanasi, Jakhini, Uttar Pradesh.
T_{19}	OKHYB-8	ICAR-IIVR, Varanasi, Jakhini, Uttar Pradesh.

Table 6 Mean performance of okra hybrids for fruit weight (g), number of fruits plant^{-1}, phenol content in leaf at 90th day after sowing (mg/100g), fruit yield (t ha^{-1}), Shoot and fruit borer and YVMV incidence rating in nineteen hybrids of okra

Treatments	Name of the hybrid	Fruit weight (g)	Number of fruits plant^{-1}	Phenol content at 90th DAS (mg/100g)	Fruit yield (t ha^{-1})	Shoot and fruit borer incidence (%)	YVMV at 90 DAS (%)
T_1	Sumithra -2000	11.28	22.32	0.54	14.02	10.78 (19.17)^{ab}	0.00 (1.28)^{d}
T_2	Sumithra -15	14.64**	15.97	0.57	13.04	12.33 (20.56)^{bc}	0.00 (1.28)^{d}
T_3	Anna-10	8.34	23.38*	0.44	10.72	9.11 (17.49)^{a}	0.00 (1.28)^{d}

T_4	Ajanta	8.79	25.24**	0.68	12.42	12.66 (20.83) [bc]	3.94(11.40) [b]
T_5	Ankur-2028	10.80	18.50	0.44	11.21	14.14 (22.09) [cde]	0.00 (1.28) [d]
T_6	Green Gold	13.80**	17.17	0.39	13.18	13.81 (21.81) [bcd]	0.00 (1.28) [d]
T_7	Texico 55	11.84	19.12	0.77**	12.62	15.45 (23.13) [bcdefg]	5.53 (13.59) [a]
T_8	Saarika	11.62	18.47	0.56	11.98	13.41 (21.48) [bcd]	0.00 (1.28)[d]
T_9	Harsha	13.35*	18.13	0.62	13.51	16.41 (23.88) [efgh]	0.00 (1.28) [d]
T_{10}	Mahy 28	11.99	21.59	0.60	14.20	21.24 (27.44) [i]	0.00 (1.28) [d]
T_{11}	Garjana 550	12.98	15.24	0.52	11.01	19.71 (26.34) [hi]	0.00 (1.28)[d]
T_{12}	CO 4	12.67	16.92	0.57	11.98	16.07 (23.51) [defg]	0.00 (1.28) [d]
T_{13}	NBH-180-C	12.44	33.07**	0.80**	22.97**	12.38 (20.61) [bc]	0.00 (1.28) [d]
T_{14}	OKHYB-2	13.22*	16.29	0.74*	11.31	17.20 (24.51)[efgh]	4.79(12.34) [ab]
T_{15}	OKHYB-3	12.14	17.07	0.44	12.57	18.67 (25.59)[ghi]	0.00 (1.28)[d]
T_{16}	OKHYB-4	10.24	21.05	0.67	14.23	21.31 (27.49)[i]	2.60 (9.28)[c]
T_{17}	OKHYB-5	11.42	18.93	0.46	10.82	14.69 (22.51)[bcdef]	0.00 (1.28)[d]
T_{18}	OKHYB-6	14.62**	27.40**	0.49	17.54**	17.22 (24.53)[efgh]	0.00 (1.28)[d]
T_{19}	OKHYB-8	12.44	13.72	0.42	11.19	17.73(24.89)[fghifghi]	0.00 (1.28)[d]
	Mean	12.03	19.98	0.56	13.18	16.13 (23.04)	1.45 (3.46)
	Range	8.34-14.64	13.72-33.07	0.39-0.80	10.72-22.97	9.11-21.31	0.00-5.53
	SEd	0.54	1.24	0.06	-	1.26	0.99
	CD (0.05)	1.15	2.61	0.14	-	2.65	2.09
	CD (0.01)	1.57	3.58	0.19	-	3.64	2.86
	CV (per cent)	4.55	6.23	12.01	-	5.49	28.75

TRANSFORMING INDIA'S HIGHER AGRICULTURAL EDUCATION SYSTEM - STRATEGIES FOR EFFECTIVE REFORMATION IN THE 21st CENTURY

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Abstract

India is an agriculturally-based nation. There were food shortages in our country at the time of independence. We later achieved food grain self-sufficiency despite an increase in population. Graduates in agriculture have a significant role to play in the success of the green revolution. In order to provide education in the area of agriculture after independence, state agricultural universities were founded in each state. The Indian Council of Agricultural Research, New Delhi, is responsible for regulating and ensuring the efficient distribution of agricultural education. Agricultural universities are also governed by the state governments that founded them because they are institutions under their jurisdiction. Agricultural universities have made a commendable effort, but in the current liberalised and globalised era of the World Trade Organization and the General Agreement on Trade in Services, they face several difficulties, including financial limitations, a lack of autonomy, inbreeding, a shortage of faculty members who are knowledgeable in more recent fields of agricultural sciences, etc. In order to ensure that there is enough food for our expanding population, it is important to take corrective action since agricultural education is a professional education. This study discusses the state of agricultural education in India, noting obstacles and offering solutions.

Key words: *Agricultural Education, Development, and Agricultural Universities.*

Introduction

An important factor in strengthening the economy and accelerating development is agricultural education. It might signify a significant step toward sustainability and food security. Human resources must be appropriately developed, and untapped agricultural potential can be unlocked by enlightening people about this verdant gem known as agriculture. The statistics of education needed for the exclusive expansion of this sector can be improved by sensitising people through awareness programmes, training sessions, and camps. Lack of knowledge and supervision is currently the largest problem our industry is facing. Education is a method of sustainability; it goes beyond just imparting knowledge. People who work in agriculture should have all the necessary skill sets to achieve the sector's optimal productivity. This paper looks at the effects of agriculture education and how it might impact the entire economy.

India's Higher Education Agricultural System Status

Agriculture, horticulture, forestry, fisheries science, food technology, veterinary medicine, and animal husbandry are just a few of the agricultural fields that agricultural institutions offer education in at the diploma, degree, master's, and doctoral levels. Over 35,000 full-time faculty

members work in agriculture and related sciences teaching, research, and extension, with an estimated 1.65 lakh students enrolled in various UG, PG, and PhD programmes at these universities.54.9% of the 7292 PhD candidates enrolled in agriculture and allied studies are male. 61.9% of men and 38.1% of women make up the 3022 graduate students in agriculture and allied industries.

General Objectives of Agricultural Education

Because current agricultural practises are more knowledge-based, it might be difficult for many of our rural farmers to become knowledgeable about them. India does require education at all levels in order to better educate its farmers to face the threats posed by globalisation. As a result of the influx of foreign direct investment (FDI) in the sector, numerous MNCs have recently entered the market with dozens of agro-products. As a result, this has created a threat to Indian farmers who lack the specialised skills to deal with the situation more effectively. Therefore, it is imperative to give agricultural education the utmost priority. Despite the agriculture industry's significant advancements, there are still numerous unresolved issues that demand prompt attention. Additionally, it is true that many farmers have killed themselves, particularly in the states of Andhra Pradesh and Maharashtra, as a result of debt and persistent crop failures. Our scientific community is making every effort to bring about paradigm shifts in agricultural education in the nation, keeping in mind that enhanced productivity and production must be the only purpose of agricultural research.

The Indian Government has developed the following programmes to promote improved Agricultural Education:

Information about the function of private investment in agriculture

Agro-based industries are being established, and efforts are being made to provide favourable economic conditions to encourage private enterprise participation. Institutions like the National Bank for Agriculture and Rural Development (NABARD), Exim Bank of India, and the Directorate of Economics & Statistics play a significant role in directing private sector investment toward the agricultural sector.

Education and information about credit options for farmers

Numerous rural financial banks have been founded to address the local credit needs of farmers. The Exim Bank of India and the National Bank for Agriculture and Rural Development (NABARD) are two banks that can be quite helpful.

Water resource usage education

Agriculture uses 70% of the water resources in India. Water pollution, ground water depletion, water logging, salinity, and desertification problems are on the rise due to several factors, including rising urbanisation, industrialisation, and excessive use of agricultural pesticides and fertilisers. To solve the problem, improved irrigation techniques must be adopted as well as education on efficient canal water management. The Ministry of Water Resources does offer educational material on the subject.

Education on solid marketing infrastructure

With a view to reducing post-harvest losses and ensuring that farmers receive higher returns, education has been concentrated on the efficient marketing infrastructure and practises of preservation, storage, and transportation, etc. Institutions like the Indian Council of Agricultural Research and the Marketing Research and Information Network (AGMARKNET) are aiming to improve and disseminate market intelligence for the rural population.

Education on the function of efficient agro processing methods

The installation of agro-processing facilities in production areas also contributes to the reduction of post-harvest waste. Farmers may save a sizable proportion of the loss with the use of efficient agro-processing technologies. The Indian Institute of Packaging is conducting excellent work in this area.

Management of Drought and Flood Education

Agricultural output will undoubtedly benefit from education about the many methods and equipment available to better combat disasters like floods and droughts. Farmers who live in those locations can benefit more from contingency agricultural planning for the areas that are vulnerable to drought and flooding. Education on the subject is also offered by the Ministries of Water Resources and National Disaster Management (Ministry of Home Affairs).

Laboratories for Soil and Water Testing

Farmers are educated by these testing labs, which are dispersed across the nation, about the numerous scientific instruments available for recognising excellent soil and water for agricultural uses. They evaluate the quality of irrigation water by analysing soil and water samples from various farms and regions. They also make the necessary recommendations for the use of various water types to solve various soil-related issues, such as acidity, salinity, and alkalinity, which unquestionably increase agricultural output.

Instruction in agricultural laws and regulations

An increase in agricultural income necessitates knowledge of various laws regarding investments in dams, canals, water harvesting, irrigation facilities, better seeds, soil testing, better fertilisers and pesticides, storage facilities, transportation, and market access, among other things. Knowledge of agricultural laws is also required in order to receive grants from various state governments. The Ministry of Rural Development (Department of Land Resources) and the Department of Agriculture and Cooperation (Ministry of Agriculture, Government of India) develop numerous policies for this sector in order to increase transparency and address legal concerns concerning ideas like VAT, etc.

Support for Agri-Price

A market intervention strategy that involves purchasing through a recognised organisation, such as the Commission for Agriculture Costs and Prices, the Agricultural & Processed Food Products Export Development Authority (APEDA), or the Marketing Research and Information Network (AGMARKNET), among others, can undoubtedly be of great assistance in ensuring fair returns for farmers.

Ideas for the Future

Indian agricultural institutes must develop policies about technology, greater market access chances, and more openness in order to effectively leverage the global competitive edge.

Recommendations for Transforming Higher Agriculture Education Systems in India

Education is a dynamic process. It is impossible to make a final judgement on it, especially in the present period. The entire system of education in the developing Indian society adapts to the evolving conditions. The country has many obstacles, including the extension of education, the universalization of basic education, higher and professional education, and overall educational quality. It must adhere to specific beliefs and adapt to a variety of conditions, including rapid population growth and political, social, and economic development. Therefore, it is necessary to study, reevaluate, and rearrange educational thoughts and practises. Teachers and teacher educators

must become familiar with international trends, internationalism, multiculturalism, multi-racialism, and other pluralities in the context of shifting globalisation, liberalisation, and technological advancements. Eminent people have made several improvements to agricultural education suggestions, and these proposals have also been addressed at appropriate forums. Due to these efforts, there has been some development, but more must be done to make it functional for the demands of the moment. The approach to governance and control, financial sustainability, accountability, autonomy, transparency, and meritocracy must be fundamentally changed in order to improve the quality and relevance of agricultural education. To adapt agricultural education to current needs, adopt the suggestions below.

At the federal level, to ensure uniformity among all the agricultural universities in the various states of India, state authorities should be required to follow ICAR norms. ICAR should take the lead in enhancing the SAUs' overall governance by ensuring that the Model Act for Agricultural Universities' provisions are followed. The ICAR has established an accreditation method. The performance and academic results from the accreditation procedure should be tied to the developmental grant. ensuring that qualified individuals are nominated for and appointed to university governing boards. adequate financial support from the ICAR and state governments. It is important to promote self-sufficiency at agricultural universities. A vice chancellor has a significant impact on how well an institution operates. Direct action by the chancellor should be taken on the selection committee's proposal. Establishment of a learning forum at the federal level, with participation from state and institutional leaders, to talk about the evolving skill requirements, difficulties SAUs face, tactics for efficient governance, deliverables, and their quality through the exchange of information, experiences, best practises, and study trips. International review committees are being established to bring Indian higher agricultural education up to par with top-tier institutions of higher learning. The international review group should include eminent educators, scientists, and researchers from both India and overseas. The primary responsibility of such a committee ought to be to develop a thorough action plan to update the Indian agriculture education system.

At the college level in an agricultural university, the Board of Management, or Board of Governors collectively, is the highest decision-making body. Therefore, the Board of Management and the Board of Governors should accept their joint and individual obligations to maintain effective governance through responsible methods. They must guarantee and uphold the autonomy and responsibility of universities. Forming committees at the college level with participation from outside experts to track and assess faculty members' performance in their work in teaching, research, and extension. Each SAU should have a master plan for its long-term and short-term human resource planning and development. Each SAU should have a master plan for its long-term and short-term human resource planning and development.

Higher Agricultural Education Capacity Building

The university's system of extension education includes human resource development as a crucial and required activity. The DOEE hosts numerous model training courses, teacher development programmes, and winter and summer schools, national, state, and internal staff training, among other things. Additionally, the directorate plans to offer farm families vocational training to help them become more self-sufficient and secure their way of life. The directorate frequently hosts short-term workshops on innovative production technology for farmers, farmwomen, and young people living in rural areas.

Training Programs

The DOEE provides national-level training courses, seminars, and workshops to advance the professional competence of the officials and extension staff employed by the many line departments of the federal government. The following are some of the main training topics: oilseeds and pulses, cropping systems approach, seed production technology, post-harvest technology, integrated pest management, desert horticulture, micro-irrigation systems, etc.

The directorate arranges brief training sessions for line department subject matter experts on topics including integrated pest management, organic farming, vermicomposting, women in agriculture, aromatic and medicinal plants, etc. In these courses, the administrators learn about current technical developments as well as emerging issues and their solutions.

The DOEE is organising winter and summer schools that are sponsored by ICAR in order to keep the scientists of SAUs up to date with the most recent developments in science and technology. Courses are being organised on advanced media communications, extension techniques, and vocational entrepreneurship for sustainable livelihood by agriculture practitioners. These topics include communication technologies and extension methodology; innovative breeding methodologies for sustainable, higher production in coarse cereals; and sustainable, higher production in coarse cereals.

Faculty Development Training

Under the Technical Backstopping programme, faculty development training is offered to DOEE scientists in order to update the skills necessary for their continued productivity. In recent years, scientists have received training in areas like impact research, tally accounting, post-harvest management, and on-farm testing.

Agribusiness education and agri-clinics

One of the acknowledged institutions in the nation offering training in agribusiness and agri-clinics is the DOEE. The Ministry of Agriculture and Cooperation has funded this training (Government of India, New Delhi). The DOEE is giving people who aren't already employed in the agriculture sector a 60-day training programme through this training. Graduates in agriculture are given this training with the intention of equipping them with the managerial and entrepreneurial skills necessary to start their own businesses and employ others. The manufacture of biofertilizers and biopesticides, rural storage facilities (or "godowns"), the selling of agricultural inputs, custom hiring, nurseries for fruit and ornamental plants, agri-clinics, retail stores, etc. are major industries where participants start their own businesses.

Farmer and farmwoman training initiatives

The directorate is putting up short-term interstate and state-level courses for working farmers and farmwomen in the fields of agricultural production, horticulture, plant protection, animal production, home science, and other relevant fields. Line departments of horticulture, soil water conservation, agriculture, and NGOs are funding these training initiatives. The participants in these trainings get hands-on experience, but they also have the chance to embrace new technology that will increase their income. Learning by doing and "Seeing is believing" are the organising tenets of these training sessions.

Conclusion

The Indian Council of Agricultural Research decided to observe December 3 as Agricultural Education Day in India in honour of Dr. Rajendra Prasad, who was born on that date in 1946 and served as the country's first president after gaining independence. India needs to urgently overhaul its agricultural education system. It permeates traditional and private universities nationwide. To satisfy consumer demand, the course curriculum must be modified. The demand for degrees in agriculture is growing faster than the supply. For students to achieve better and more fruitful results from India's agriculture courses, many sorts of training and workshops are required. Students must be made aware of the significance and range of higher agricultural education. Through its constituent and affiliated colleges, India has the largest agriculture education network in the world, offering facilities for instruction in 12 undergraduate disciplines and 96 postgraduate subjects. To produce a quality outcome, the agriculture higher education system must attract talents. It could be accomplished by making agriculture education a more appealing, lucrative, and reputable career option for young people. Government funding and scholarships need to be enhanced based on the merit of students to attract more students to the agriculture higher education system. Some studies show that there is a demand-supply gap in higher agricultural education, so this situation demands proactive policies to encourage the private sector in agricultural education. In order to produce high-quality results, the higher education system for agriculture has to draw in talent. It could be accomplished by promoting agriculture as an attractive, lucrative, and respectable job for young people. To draw more students to the higher education system for agriculture, government financing and scholarships must be improved based on student merit. According to certain studies, there is a demand-supply imbalance in higher agricultural education. As a result, proactive policies are needed to support the private sector in agricultural education.

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SESAME YIELD IMPROVEMENT TECHNIQUES

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Abstract

A field experiment was conducted in a farmers field at Pondicherry state to study the effect of foliar application of various liquid organic and inorganic fertilizers along with 75 Per cent recommended NPK on the growth and yield of Sesame. The experiment comprised of 10 treatments, conducted in RBD with three replications. The result revealed that application of 75 % NPK along with foliar application of Panchagavya @ 3 per cent on 25 and 40 DAS ranks first with a plant height of 70.3 cm, number of branches 17.3, number of leaves 110.3, DMP 1107 Kg/ha, seed yield 669 Kg/ha and stover yield of 2189 kg/ha.

Key words: *Panchagavya, seaweed, Fish meal extract, Humic acid, DAP, NAA*

Introduction

Sesame is an oldest indigenous oilseed crop with longest history of cultivation in India. Sesame is an important oil seed crop grown in the world and in India its place is next to groundnut, mustard, and rapeseed. India ranks first in the world and it is the largest producer of sesame catering to the world market. In the year 2018-19, the production was 8.66 lakh tons from 19.47 lakh hectares with average productivity of 413 kg/ha. Using of more chemical fertilizer causes harmful effect on soil, water and causing the environmental pollution. However, N useefficiency is 30 – 50%, the P use efficiency is 15 – 20% and K use efficiency is 70-80 %. Higher amount of chemical fertilizer like NPK increases pollution, decreases soil productivity, soil fertility and leads to nutrient imbalance. Thus, sustainable agricultural production is not guaranteed while using on chemical fertilizers (Umar *et al.*, 2011). Sustainability of crop production is not a viable proposition either through use of organic manures or chemical fertilizers alone. Use of chemical fertilizers alone increased the crop yields in the initial years but adversely affected the sustainability at alater stage. Continuous use of chemical fertilizer causes deficiency of nutrients in the soil (Parmar *et al.*, 2020). Fertilizer application to sesame in either natural or inorganic forms is a key segment to great development, high return, high seed quality, and oil content. Nitrogen is the most dynamic nutrient element and the most important nutrient that is required for the survival of all living things.

Materials and Methods

A field experiment was carried out with sesame variety TMV-7 in farmer's field at Thirukkanur village, Villianur taluk, Puducherry state during February to April of 2021. The experimental soil is clayey loam in texture. The soil is low in available nitrogen (112 Kg/ha), medium in available phosphorus (14 Kg/ha) and medium in available potassium (170 Kh/ha). The crop was sown with a spacing of 30x30 cm. The experiment was conducted in randomized block design with ten treatments and three replication. The ten treatments were, 100% recommended NPK (T1), 75% NPK (T2), 75% NPK + Panchagavya spray @ 3% on 25 and 40 DAS (T3), 75% NPK + Vermiwash spray @ 25% on 25 and 40 DAS (T4), 75% NPK + Vermiwash spray + Cow's urine spray @ 20% each on 25 and 40 DAS (T5), 75% NPK + Fish meal extract spray @ 2% on 25 and 40 DAS (T6), 75% NPK + Pasumai gold (Humic acid) @ 5ml/l on 25 and 40 DAS (T7), 75% NPK + Biovita (Sea weed extract) @ 5ml/l on 25 and 40 DAS (T8), 75% NPK + DAP @ 2% + NAA @ 40 ppm on 25 and 40 DAS. (T9), 75% NPK + Neem coated urea @ 1% on 25 and 40 DAS

(T10). A fertilizer schedule 35:23:23 Kg NPK/ha was adopted for 100% RDF from which 75% NPK was calculated (26.25:17.25:17.25) and applied to the plots as per treatment schedule. The entire quantities of NPK were applied basally through urea, Single Super Phosphate and Muriate of Potash. All the organic and inorganic solutions were prepared at required concentrations and were sprayed on 25 and 40 DAS to the respective plots as per treatment schedule using knapsack sprayer with 500 l of water.

Results and Discussion

Plant height

All the treatments significantly influenced the plant height (Table -1). Application of 25% less than recommended dose of NPK resulted in reduction in plant height to the tune of 3.6 cm at 55 DAS compared to 100 % NPK application. However, this reduction in plant height was improved due to foliar application of various organic and syntheticfertilizer sources. The growth components like plant height, number of leaves, number of branches, dry matter production were enhanced due to foliar application of these sources along with 75% recommended dose of fertilizer. Among the treatments tried, 75% NPK + Panchagavya spray @ 3%foliar spray (T3) ranked first and resulted in the tallest plants with a value of 70.3 cm.This was followed by (T5) 75% NPK + Vermiwash spray + Cow's urine spray @ 20%each (67.5 cm) and it was found to be on par with (T4) 75% NPK + Vermiwash spray @ 25% (67.3 cm). Among the foliar application of various organic sources along with 75% NPK, the performance of panchagavya was found to be the best. Application of 75% NPK +DAP @ 2% + NAA @ 40 ppm (T9) and 75% NPK + Neem coated urea @ 1% (T10) increased the plant heights significantly compared to 75% NPK application alone. Foliar application of 75% NPK + DAP @ 2% + NAA @ 40 ppm (T9) was found to bebetter compared to 75% NPK + Neem coated urea @ 1% (T10) and improved the plant height to the tune of 5.5 cm. The least plant height of 51.8 cm was recordedin 75% NPK application alone (T2).

Number of branches/Plant

All the treatments conspicuously influenced the number of branches/plants. Application of 25% less than recommended dose of NPK resulted in reduction in branches to the tune of 1.7 compared to 100 % NPK application. However, this reduction in branches was improved due to the foliar application of various organic and synthetic fertilizer sources. Among the treatments tested, 75% NPK + Panchagavya spray @ 3% foliar spray (T3) surpassed other treatments and resulted in the highest number of branches (17.3). The better performance of the treatments where in 75% recommended NPK was applied might be due to the combined role of nitrogen which is a component of amino acids, enzymes, chlorophyll and hormones, application of phosphorus basally might have utilised by the plant for its root development, uptake of water and nutrients and Potassium might have helped in protein synthesis, enzymes, and grain filling. The similar result can be found with the findings of Kashani *et al.,* (2015). This was followed by (T5) 75% NPK + Vermiwash spray + Cow's urine spray @ 20% each (14.6) and it was on par with (T4) 75% NPK + Vermiwash spray @ 25%. Among the foliar application of various organic sources along with 75% NPK, the performance of panchagavya was found to be the best. Application of 75% NPK + DAP @ 2% + NAA @ 40 ppm (T9) and 75% NPK + Neem coated urea @ 1% (T10) increased the number of branches significantly compared to 75% NPK application alone. The lowest number of branches/plants of 6.6 was noticed in 75% NPK application alone (T2).

Number of leaves/Plant

All the treatments significantly influenced the number of leaves/plants. Application of 25% less than recommended dose of NPK resulted in reduction in number of leaves to the tune of 6.00 compared to 100 % NPK application. However, this reduction in leaf number was improved due to the foliar application of various organic and synthetic fertilizer sources. Among the treatments tried, 75% NPK + Panchagavya spray @ 3% foliar spray (T3) ranked first and resulted in the highest number of leaves/plants (110.33). Supplemental foliar application of Panchagavya might have enhanced the biological efficacy of crops due to the presence of macronutrients, micronutrients, and growth stimulants. Same result was earlier reported by Nileema and Sreenivasa, (2011). This was followed by (T5) 75% NPK + Vermiwash spray + Cow's urine spray @ 20% each as (107.00) and it was comparable with (T4) 75% NPK + Vermiwash spray @ 25%. Among the foliar application of various organic sources along with 75% NPK, the performance of panchagavya was found to be the best. Application of 75% NPK +DAP @ 2% + NAA @ 40 ppm (T9) and 75% NPK + Neem coated urea @ 1% (T10) increased the number of leaves significantly compared to 75% NPK application alone.Foliar application of 75% NPK + DAP @ 2% + NAA @ 40 ppm (T9) was found on par with 75% NPK + Neem coated urea @ 1% (T10). The least number of leaves/plants of 86.66 was recorded in 75% NPK (T2) application alone.

Drymatter Production

All the treatments significantly influenced the dry matter production. Application of 25% less than recommended dose of NPK resulted in reduction in DMP to the tune of 53 kg/ha compared to 100 % NPK application. However, this reduction in DMP was improved due to foliar application of various organic and synthetic fertilizer sources. Among the treatments, 75% NPK + Panchagavya spray @ 3% foliar spray (T3) excelled rest of the treatments and resulted in the highest dry matter production of 1107 kg/ha. This might be due to NPK application plus IAA and GA present in panchagavya when applied as foliar spray could have created the stimuli in the plant system and increased the production of growth regulators in cell system and ultimately stimulated the necessary growth. The next in order was (T5) 75% NPK + Vermiwash spray + Cow's urine spray @ 20% each and all of them were comparable with (T4) 75% NPK + Vermiwash spray @ 25% and (T8) 75% NPK + Biovita (Seaweed extract) spray. Among the foliar application of various organic sources along with 75% NPK, the performance of panchagavya was found to be the best. Application of 75% NPK +DAP @ 2% + NAA @ 40 ppm (T9) and 75% NPK + Neem coated urea @ 1% (T10) increased the dry matter production significantly compared to 75% NPK application alone. Foliar application of 75% NPK + DAP @ 2% + NAA @ 40 ppm (T9) and 75% NPK + Neem coated urea @ 1% (T10) exerted similar effect in influencing DMP. The least dry matter production of 673 kg/ha was recorded in 75% NPK application alone

Seed Yield

Among the treatments, 75% NPK + Panchagavya spray @ 3% foliar spray (T3) resulted with a seed yield of 669 kg/ha and it is only numerically superior to other treatments. This might be due to the early and continuous availability of nutrients from NPK application @ 75% and the presence of macro, micro nutrients, plant growth substances and microorganisms present in panchagavya which might have enhanced the plant growth and it is reflected in terms of yield. This result are in the agreement with findings of Hardik Patel *et al.*, (2018). An identical seed yield of 642 kg/ha was observed in (T5) 75% NPK + Vermiwash spray + Cow's urine spray @ 20% each and (T4) 75% NPK + Vermiwash spray @ 25%. Among the foliar application of various organic

sources along with 75% NPK, the performance of panchagavya was found to be the better and increased the seed yield upto 18.8% compared to 75% NPK application alone. Application of Biovita (Seaweed extract) or Pasumai gold (Humic acid) or Fish meal extract along with 75% NPK increased the seed yield to the tune of 285, 217 and 213 Kg/ha respectively over 75% NPK application alone. The better performance of Pasumai gold combination with NPK might be due to the combination of amino acids, fulvic acid and auxins present in the commercial product which stimulated the growth and enhanced the catalytic activity, cell permeability, increased the biochemical processes and uptake of macronutrients as it was evident from the growth parameters recorded in this treatment. This result was earlier mentioned by Jahan *et al.*, (2019). Better performance of fish meal extract might be due to the presence of amino acids, auxins, nutrients and microorganisms present in it which might have promoted the cell division, cell elongation and resulted in taller plants, more number of leaves, LAI and DMP. Biovita contain seaweed extracts which is a liquid organic fertilizer contains nutrients which when applied along with 75% recommended NPK stimulated the crop growth resulted in better growth and yield parameters. Application of 75% NPK + DAP @ 2% + NAA @ 40 ppm (T9), 75% NPK + Neem coated urea @ 1% (T10) and (T7) 75% NPK + Pasumai gold (Humic acid) spray @ 5 ml/l did not differ significantly with 75% NPK application alone. The least seed yield of 563 kg/ha was recorded in 75% NPK application alone (T2).

Stover yield

All the treatments markedly influenced the stover yield. Application of 25% lessthan recommended dose of NPK resulted in reduction in stover yield to the tune of 177 kg/ha compared to 100 % NPK application. However, this reduction in stover yield was improved due to foliar application of various organic and synthetic fertilizersources. Among the treatments, 75% NPK + Panchagavya spray @ 3% (T3) ranked first compared to other treatments and resulted in a stover yield of 2187 kg/ha. The next in order was (T5) 75% NPK + Vermiwash spray + Cow's urine spray @ 20% each, (T4) 75% NPK + Vermiwash spray @ 25% and (T8) 75% NPK + Biovita (Seaweed extract) spray @ 5ml/l and all were on par. Among the foliar application of various organic sources along with 75% NPK, the performance of panchagavya was found to be better and increased the stover yield upto 378 kg/ha compared to 75 % NPK application alone. Application of 75% NPK + DAP @ 2% + NAA @ 40 ppm (T9) and 75% NPK + Neem coated urea @ 1% (T10) increased the stover yield significantly compared to 75% NPK application alone. Foliar application of 75% NPK + DAP @ 2% + NAA @ 40 ppm (T9) increased the stover yield to the tune 2 kg/ha over 75% NPK + Neem coated urea @ 1% (T10). The lowest stover yield of 1809 kg/ha was noticed in 75% NPK application alone (T2).

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Table -1. Effect of foliar feeding on growth and yield of sesame

Treatment	Plant height at 55 DAS cm	Number of branche s/plants at 55 DAS	Number of leaves/plant s at 55 DAS	DMP at 55 DASKg/ha	Seed Yield Kg/ha	Stover Yield Kg/ha
T1-100% Recommended NPK	55.4	8.3	92.66	726	597	1986
T2 - 75% NPK	51.8	6.6	86.66	673	563	1809
T3 - 75% NPK + Panchagavya spray @ 3% on 25 and 40 DAS	70.3	17.3	110.33	1107	669	2187
T4 - 75% NPK + Vermiwash spray @ 25% on 25 and 40 DAS	67.3	14.3	106.33	1018	642	2089
T5 75% NPK + Vermiwash spray + Cow's urine spray @ 20% each on 25 and 40 DAS	67.5	14.6	107.00	1026	642	2091
T6 - 75% NPK + Fish meal extract spray @ 2% on 25 and 40 DAS	63.4	11.0	99.33	886	619	2017
T7-75% NPK + Pasumai gold (Humic acid) @	63.6	11.3	100.33	890	624	2028

5ml/l on 25 and 40 DAS						
T8 -75% NPK + Biovita (Sea weed extract) @ 5ml/l on 25 and 40 DAS	65.4	12.6	103.33	958	11.6	2057
T9 - 75% NPK + DAP @ 2% + NAA @ 40 ppm on 25and 40 DAS	60.4	9.6	95.33	823	9.0	1994
T10 - 75% NPK + Neem coated urea @ 1% on 25 and 40 DAS	55.4	8.3	92.66	765	23.6	1992
S. Em ±	0.99	0.35	1.30	24.9	19.6	34.0
C.D (p=0.05)	2.99	1.06	3.90	74.9	20.0	102.2

ASSESSMENT OF VULNERABILITY TO CLIMATE CHANGEON SUGARCANE PRODUCTION IN TAMIL NADU

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Abstract

Noble cane (Sugar cane - Saccharin officinarumL.) is an important commercial crop worldwide next to cotton. Globally, 78 per cent of the sugar is produced from sugarcane, rest is produced from sugar beets. Climate change is one of the biggest challenges the world facing today. The climate vulnerability assessment has different stages. The variables that contributed to climatic vulnerability were first identified in the first stage. Then the variables were in different units of measurement and had positive or negative impacts on vulnerability. Based on that the functional relationship was given to the variables. The functional relationship will help to identify the weightage to the variables. According to IPCC, the contributing factors to vulnerability to climate variability have been classified into adaptive capacity, exposure, and sensitivity to climate variability. The vulnerability index was estimated with 14 variables. Thiruppur district is 'Highly Vulnerable' to climate change with (0.93) followed by Kanniyakumari (0.71) and Ariyalur (0.70). Mostly Kanniyakumari district registered lowest area under sugarcane cultivation so that sensitivity index of that district was higher and in case of Ariyalur district, it was bifurcated in 2008 so that it's sensitivity index also high. Adaptive capacity was high compared to sensitivity and exposure index for Viluppuram and Thiruvannamalai districts. Viluppuram district comes under the least vulnerable category which means climate change does not create more impact on sugarcane yield and the growth of area, production and yield shows an increasing trend.

Introduction

Climate change is one of the biggest challenges facing the world today. The problem of human induced climate change first came into force and drew the attention of scientists and policy makers, when Inter-Governmental Panel on Climate Change (IPCC) was established. The issue of climate change threatens to have far reaching environmental disturbances that could have a severe impact on people throughout the world. It is important to understand the nature of the risks from climate change, where natural and human systems are likely to be most vulnerable and what may be achieved by adaptive responses.

As the Indian economy is closely tied to its natural resource base, it is considered vulnerable to the impacts of climate change. For instance, the decade of the 1990’s has been the most influential in terms of increase in temperature and decrease in precipitation among the last 100 years (IPCC, 1998). The mean surface temperature during the last 100 years in India increased by 0.3^{O} to 0.8^{O}C which is mostly due to the climate change in the period specified. An increase in mean temperature for the next 50 years in India is projected at 0.7^{O} to 1^{O}C.Developing countries are more vulnerable to climate change than developed countries because of the predominance of agriculture in their economies and scarcity of capital for adaptation measures (Fischer, 2005). Sinha and Swami Nathan (1991) have showed that an increase of 2^{O}C in temperature would decrease rice yield by about 0.75 ton/ha.

Tamil Nadu is one of the states, which is often affected by natural calamities. Its rainfall is highly variable with a normal annual average of 958.5 mm. The net sown area of Tamil Nadu is

about 40 percent and the gross sown area is about 47 per cent of the total geographical area. Tamil Nadu has eleven coastal districts which share 25.5 per cent of the total geographical area. Due to high fluctuation in the rainfall, Tamil Nadu farmers suffer heavy losses in the production of crops. Hence, an assessment of vulnerability in the districts of Tamil Nadu will help to properly anticipate and adapt farming to maximize sugarcane production in the state.

The climatic vulnerability is measured using the following indexes: i) Exposure is defined as "the existence of individuals, livelihoods, species, or ecosystems, environmental functions, services, resources, infrastructure, or economic, social, or cultural assets in locations and situations that may be negatively impacted." (IPCC 2014). ii) Sensitivity is "the extent to which a system is influenced by climate-related stimuli, either favourably or unfavourably. The result could be immediate (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature, rainfall and precipitation) (IPCC 2001). iii) Adaptive capacity is "the ability of a system to react to climate change (including climate variability and extremes), to minimise possible harms, to take advantage of opportunities, or to cope with the consequences"(IPCC 2001).

Taking into consideration of the water scarcity and climate change impact on sugarcane production, the present study aims at climate vulnerability sugarcane farmers of Tamil Nadu.

Vulnerability Indicators

The first step in vulnerability assessment is the identification of suitable indicators that fully account for the complexity of the system under study. In this method, the variables that contributed to climatic vulnerability were first identified. Then the variables were in different units of measurement and had positive or negative impacts on vulnerability. Based on that the functional relationship was given to the variables. The selected variables are presented in Tables1, 2 and 3. The districts have been selected before bifurcate in 2019.

Exposure is the nature and degree to which a system is exposed to climate change. Sensitivity is the degree to which a system is adversely affected by climate change. Sensitivity and exposure in combination are termed as 'potential impact' which is highly detrimental to the region if the degree of the index is more. Alternatively, adaptive capacity is the ability of a region or production system to better adjust to the climatic risks, variability, and impact due to climate change. The vulnerability index of a region is the degree of potential impact over the adaptive capacity of that region.

Table 1. Variables on sensitivity and their functional relationship

S. No	Variables	Functional relationship
1	Area, production, and yield (TE 2020-21)	Negative
2	Percentage change in the area, production, and yield (TE - 2006 -07 to TE – 2020-21)	Positive
3	Potential loss (TE - 2006 - 07 to TE – 2020 - 21)	Negative
4	Share of sugarcane in gross cropped area (2014 - 15)	Negative
5	Groundwater level (August, 2019)	Positive

Table 2. Variables on exposure and their functional relationship

S. No	Variables	Functional relationship
1	Maximum temperature	Negative
2	Minimum temperature	Negative
3	Precipitation	Negative

Table 3. Variables on adaptive capacity and their functional relationship

S. No	Variables	Functional relationship
1	Rural literacy rate (2011 census)	Negative
2	Growth of area, production and yield (2006-07 to 2020-21)	Negative
3	Net irrigated area (2011 census)	Negative
4	Area under drip irrigation (2020-21)	Positive
5	Average farm size (2011 census)	Negative

Materials and Methods

Climate Vulnerability

Normalisation of data

The collected data on different variables were normalised to make them unit and scale free for comparison using the approach as outlined in Sendhil*et al.* (2017) irrespective of study domain. For variables that have a positive functional relationship with the respective indicators, normalisation has been done as given in equation 1.

$$\text{Normalisation} = \frac{(\text{Actual value - Minimum value})}{(\text{Maximum value - Minimum value})} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

For variables that influence the respective indicators negatively, the following normalisation formula equation 2 has been used:

$$\text{Normalisation} = \frac{(\text{Maximum value - Actual value})}{(\text{Maximum value - Minimum value})} \quad \ldots\ldots (2)$$

Assigning weights to variables

After normalising the data which results in observations lying between 0 and 1 for all variables, weights must be assigned to the respective variables for computing the composite index. Normally, weights can be assigned in three possible ways (Kumar *et al.,* 2016): equal weights, expert opinion and principal component analysis (PCA). Each method has its own advantages and disadvantages. Equal weights may undermine some variables which largely influence the index; expert opinion will be subjective and limited to the availability of experts, number of variables and research time to get the response and PCA requires econometric knowledge and works with the assumption that linear relationship exists among variables. In the present study, considering the use of multi-dimension data and the advantage of PCA over other methods, weights have been assigned by

performing the principal components analysis. Unlike studies that use only the factor loadings from first principal component for assigning weights (Kumar *et al.,* 2016), we followed the criterion (selecting the principal components with an Eigen value of more than one) which accounts for maximum variation in the data as given in Ayyoob*et al.* (2013) and Sendhil (2018) under the following framework (Eq. 3).

$$X_t = A_t F_t + e_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

X_t represents the N-dimensional vector of variables influencing vulnerability,

A_t is the rx1 common factor,

Ft is the factor loading and

et is the associated idiosyncratic error-term of order N x 1

The weights from the PCA were calculated as indicated by equation 4.

$$Wi = \Sigma \left| L_{ij} \right| E_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where,

W_i is the weight of the i^{th} variable

E_j is the Eigen value of the j^{th} factor

L_{ij} is the loading value of the i^{th} variable on j^{th} factor.

Composite vulnerability indexing and categorisation

Expressing the above calculated weights for each variable for all the selected sugarcane producing districts in the following formula (Eq. 5) will give a composite index value for each district.

$$\mathrm{Index}_{\mathrm{State}} = \frac{\sum_{i=1}^{n} X_i W_i}{\sum_{i=1}^{j} W_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where,

X_i is the normalized value of i^{th} variable

W_i is the weight of the i^{th}variable

Finally, the composite vulnerability in sugarcane agro-ecologies have been classified into three categories viz., high, moderate and least (Table 3.6) based on the distribution of composite index value (Ayyoob*et al.,* 2013).

Table 4. Different category of Vulnerability Index

S. No.	Category	Ranges
1	Highly Vulnerable	Index > (Mean + 0.5 SD)
2	Moderately Vulnerable	(Mean – 0.5 SD) < Index < (Mean + 0.5 SD)
3	Least Vulnerable	Index < (Mean – 0.5 SD)

*SD- Standard Deviation

Climate vulnerability to sugarcane production in all districts of Tamil Nadu

According to IPCC, the contributing factors to vulnerability of the farmers to climate variability have been classified into adaptive capacity, exposure andsensitivity to climate variability. The vulnerability index was estimated with 14variables. In first step the data were normalised and then weights for each variable was assessed after that the composite vulnerability index was worked out.

In order to fully understand the determinants of agricultural vulnerability, the exposure, sensitivity, and adaptive capacity levels across the districts have been studied together as under composite vulnerability indices in sugarcane production given in the below Table 5. Thus, the derived indices of all the three components of agricultural vulnerability are aggregated to codify the relative agricultural vulnerability among all districts of Tamil Nadu.

Considering Viluppuram and Thiruppur districts the composite vulnerability index exhibited huge difference. Having moderate sensitivity but high exposure and low adaptive capacity, Namakkaldistrict fall under 'Moderately Vulnerable' category. Adaptive capacity was high compared to sensitivity and exposure index for Viluppuram and Thiruvannamalai districts. Adaptive capacity was very low compared to sensitivity and exposure index for Ariyalur, Coimbatore and Thiruppur districts. The climate vulnerability categories are differentiated based on colours in Tamil Nadu district wise map. Red colour indicates high vulnerability, yellow indicates moderate and green indicates least vulnerability.

Thiruppurdistrict is 'Highly Vulnerable' to climate change with the value of (0.93) composite vulnerability index followed by Kanniyakumari (0.71) and Ariyalur (0.70). Mostly Kanniyakumari district registered lowest area under sugarcane cultivation so that sensitivity index of that district was higher and in case of Ariyalur district, it was bifurcated in 2008 so that it's sensitivity index also high.

Finally, Viluppuram district comes under the least vulnerable category which means climate change does not create more impact on sugarcane yield and the growth of area, production and yield shows an increasing trend. These results are in conformation with the findings of Varadhan and Kumar (2015).

Table 5. Composite vulnerability indices in Sugarcane production

*Mean = 0.4909 and Standard Deviation = 0.1632

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District	Sensitivity Index	Exposure Index	Adaptive Capacity	Vulnerability Index	Category
	A	**B**	**C**	**A+B-C**	
Ariyalur	0.50	0.51	0.31	**0.70**	High
Coimbatore	0.73	0.49	0.58	**0.64**	High
Cuddallore	0.60	0.51	0.66	**0.45**	Moderate
Dharmapuri	0.70	0.54	0.77	**0.48**	Moderate
Dindigul	0.69	0.53	0.66	**0.56**	Moderate
Erode	0.64	0.55	0.67	**0.52**	Moderate
Kancheepuram	0.63	0.48	0.65	**0.47**	Moderate
Kanniyakumari	0.72	0.65	0.66	**0.71**	High
Karur	0.61	0.42	0.65	**0.38**	Low
Krishnagiri	0.65	0.56	0.72	**0.49**	Moderate
Madurai	0.64	0.58	0.70	**0.52**	Moderate
Nagapatinam	0.65	0.40	0.60	**0.45**	Moderate
Namakkal	0.56	0.67	0.68	**0.55**	Moderate
Perambalur	0.69	0.61	0.69	**0.60**	High
Pudukkottai	0.63	0.40	0.67	**0.36**	Low
Ramanathapuram	0.62	0.33	0.66	**0.29**	Low
Salem	0.64	0.60	0.70	**0.54**	Moderate
Sivagangai	0.63	0.33	0.67	**0.29**	Low
Thanjavur	0.64	0.44	0.62	**0.47**	Moderate
The Nilgiris	0.60	0.60	0.62	**0.59**	High
Theni	0.63	0.45	0.68	**0.40**	Moderate
Thiruchirapalli	0.65	0.42	0.65	**0.42**	Moderate
Thirunelveli	0.65	0.60	0.64	**0.62**	High
Thiruppur	0.57	0.58	0.21	**0.93**	High
Thiruvallur	0.59	0.70	0.65	**0.63**	High
Thiruvannamalai	0.56	0.51	0.69	**0.39**	Low
Thiruvarur	0.63	0.40	0.65	**0.38**	Low
Thoothukudi	0.63	0.39	0.61	**0.40**	Moderate
Vellore	0.69	0.49	0.68	**0.49**	Moderate
Viluppuram	0.20	0.51	0.73	**-0.02**	Low
Virudhunagar	0.64	0.55	0.66	**0.54**	Moderate

EFFECT OF PLANT GROWTH REGULATORS ON ROOTING OF LEAF CUTTING IN GUAVA (*Pisidium guajava* L.) cv. ARKA KIRAN

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Abstract

An experiment was conducted in the Tamizh nursery garden, Puthukooraipettai, Virudhachalam, Tamil Nadu, India during 2019-2021 to elucidate information on the effect of plant growth regulators on rooting of leaf cutting in guava (Psidium guajava L.) cv. Arka Kiran. The experiment was conducted in completely randomized block design with thirty-nine treatments in three replications. The treatments comprised of IBA and NAA with four different concentrations of 125, 250, 500 and 1000 ppm. The guava leaf cuttings were dipped in the growth regulators for 5 minutes and then planted in the polybags and they were kept in the mist chamber. The results of the above experiment revealed that the root parameters viz., rooting percentage (%), number of roots per cuttings, root length (cm). fresh weight of roots (g), dry weight of roots (g) and girth of roots (cm) were recorded maximum in the treatment where IBA @ 250 ppm + NAA @ 250 ppm was used. The lowest root parameters were recorded in the control. The various shoot parameters viz., days taken for shoot initiation, number of leaves per shoot, length of shoot (cm), girth of the shoot (cm) and survival Percentages of rooted cuttings (%) were observed the highest in the treatment where IBA @250 ppm + NAA @ 250 ppm was used. The least shoot parameters were observed in the control.

Hence, from the above experiment, it can be concluded that the growth regulators IBA @ 250 ppm + NAA @ 250 ppm performed best based on the root and shoot parameters when compared to other treatments.

Keywords: *Rooted cuttings, Growth regulators, Mist chamber and Guava leaf cuttings*

Introduction

Guava (*Psidium guajava* L.) is a delicious fruit that belongs to the myrtaceae family, known for its botanical richness and very high agro industrial potential with 121 genera and 5,800 species of aromatic fruits, classified by (Farias *et al*., 2020). It is also called as the “Poor man’s apple” and contains high vitamin C, mineral content and pectin.

To maximize the production genuine and quality planting material is a pre-requisite. For the above purpose, a rapid method for multiplying the planting material is needed to obtain good quality plants. To obtain ideal planting material, vegetative propagation like cutting is the less expensive, rapid and simplest method of multiplication of plants. The plant obtained from cuttings is true -to-type.

The plant growth regulators are used for rooting, auxins like IBA (Indole-3-butyric acid) was recorded to be superior overall. The reason of applying auxin (IBA & NAA) to the cuttings is to increase the percentage of rooting, hasten root initial stage, increase the number of roots per cuttings and to produce uniformity in rooting.

Materials and Methods

The present investigation entitled "Effect of plant growth regulators on rooting of leaf cuttings in Guava (*Psidium guajava* L.) cv. Arka Kiran" was carried out at the Tamizh nursery garden, Pudhukooraipettai, Virudhachalam, Cuddalore district during 2020-2022.

Location: Pudhukooraipettai is situated at 11^{o}C 52'N latitude and 79^{o}C 35'E longitude at an altitude of 8.0 m above MSL.

Experimental design and details

Crop	: Guava (*Psidium guajava* L.)
Design	: Completely Randomized Block Design
Replication	: Three
Rooting environment	: Under mist chamber
Variety	: Arka Kiran
Type of cutting	: Leaf cutting
Container and medium	: Polyethylene bags, sand, soil, FYM,red earth and coir dust
No of cuttings / treatment / replication	: 20 per treatment, 260 per replication
No of cuttings per polyethylene bag	1
Total number of cuttings	: 780

Experimental Results

The results of present investigation entitled "effect of plant growth regulators on rooting of leaf cuttings in guava (*Psidium guajava* L.) cv. Arka Kiran" are presented in this chapter.

Treatment details	Rooting %	No. of roots / cuttings	Length of roots/cuttings	Grith of the roots	Number of days shoot initiation	Number of leaves per Shoot	Shoot length
T1 - IBA @ 125 ppm - 5 minutes	57.25	15.62	13.34	0.19	53.70	3.54	10.98
T2 - IBA @ 250 ppm - 5 minutes	61.30	16.19	14.41	0.20	52.78	3.79	11.39
T3 - IBA @ 500 ppm - 5 minutes	65.08	16.84	15.48	0.21	51.80	4.02	11.78
T4 - IBA @ 1000 ppm - 5 minutes	68.99	17.34	16.55	0.22	50.06	4.26	12.17
T5 - NAA @ 125 ppm -5 minutes	40.83	13.39	9.09	0.16	57.41	2.38	9.47
T6 - NAA @ 250 ppm -5 minutes	45.09	14.07	10.16	0.17	56.51	2.60	9.84
T7 - NAA @ 500 ppm -5 minutes	49.07	14.59	11.23	0.18	55.54	3.08	10.21
T8 - NAA @ 1000 ppm -5 minutes	53.07	15.09	12.30	0.18	54.60	3.31	10.61
T9 - IBA @ 62.5 ppm + NAA @ 62.5 ppm - 5 minutes	72.81	17.95	17.62	0.23	49.14	4.48	12.58

T10 - IBA @ 125 ppm + NAA @ 125 ppm - 5 minutes	76.62	18.43	18.69	0.24	48.17	4.69	12.96
T11 – IBA @ 250 ppm + NAA @ 250 ppm - 5 minutes	86.45	19.72	20.83	0.26	46.41	4.92	13.76
T12 – IBA @ 500 ppm + NAA @ 500 ppm - 5 minutes	85.29	19.51	20.76	0.26	47.26	4.88	13.64
T13 - Control (Distilled water)	36.47	12.86	8.01	0.15	58.38	2.15	9.02
S.ED	1.06	0.25	0.46	0.005	0.15	0.10	0.19
CD (P=0.05)	2.12	0.52	0.94	0.01	0.31	0.21	0.36

Discussion and Result

Guava is propagated through sexual method as well as vegetative methods of propagation. Though guava can be successfully propagated by seeds but the vegetative methods of propagation are preferred as through seedling propagation genetic purity cannot be maintained since it can result in genetical variations which can affect the fruit quality, shape size and yield. And seedling plants take 6-7 years to come into bearing stage therefore they are used to raise rootstocks for budding and grafting. There are many methods of vegetative propagation in Guava like layering, cutting, grafting, stooling and budding.

Plant Growth Regulators are used in agricultural and horticultural technology to stimulate the developmental processes of the plants. They can be used for various purposes like germination, vegetative and reproductive development, senescence etc. There are mainly five categories of plant growth regulators: Auxin, Cytokinin, Gibberellin, Ethylene, and Abscisic acid.

The percentage of rooting was maximum (86.29%) in cuttings treated with T11 (IBA @ 250 ppm + NAA @ 250 ppm). Rooting of cuttings intensified by IBA through polysaccharide hydrolysis which provides energy for meristematic tissues and thereby for root primordial formation (Husen and pal, 2007).

The enhanced hydrolytic activity in presence of applied IBA might be responsible for the increased percentage of rooted cuttings. High carbohydrate and low nitrogen have been reported to favour root formation (Singh and Tomar, 2015).

The Number of roots per cutting was maximum (19.72) in cuttings treated with T11 (IBA @ 250 ppm + NAA @ 250 ppm). The reason for the better rooting and increase in root growth with various auxins treatment might be due to maximum utilization of sugar and starch after hydrolysis (Singh, 2001). (Hartman *et al.*, 2002) reported that application of IBA would be more effective to increase the rooting ability of guava cuttings.

The root length was maximum (20.83 cm) in cuttings treated with T11 (IBA @ 250 ppm + NAA @ 250 ppm). The increased size of roots may be due to auxin which plays an important role in metabolic activity and cell division process of cuttings, resulting into increased growth of roots (Edmond *et al.*, 1997).

The Girth of the root per cutting was maximum (0.26 g) in cuttings treated with T11 (IBA @ 250 ppm + NAA @ 250 ppm. The girth of the root per cutting was the least inthe control (0.25g). The increase in root girth might be because of th best favourable increase in the endogenous auxins level in lower portion of ringed branch. This is probably because higher concentration of IBA promoted the cell division which increased the diameter of primary root. Similar observation was also obtained by Kumar *et al.*(2004) and Deb *et al.* (2009).

The earliest shoot initiation (46.41 days) was noticed in cuttings treated with (T11) IBA @ 500 ppm + NAA @ 500 ppm. In control the guava cuttings took the maximum number of days (58.38 days) for shoot initiation to appear. Similar results were also reported byKumar *et al.* (1995), Awasthi *et al.* (2008), Thankamani *et al.* (2005) and Kour *et al.* (2006).

The number of leaves per shoot was maximum (4.92) in cuttings treated with T11 (IBA @ 250 ppm + NAA @ 250 ppm). The least number of leaves per shoot (2.17) was recorded in T13 (control). These findings are in agreement with earlier workers Chandramouli (2001), Singh *et al.* (2003) and Kumar *et al.* (2004) Paul and Aditi (2009) in waterapple, Tomar *et al*. (2011) in jackfruit, Patel *et al*. (2012) in pomegranate, Raut *et al*. (2015) in Karonda, Peter and Prasad (2016) in lemon, Munde *et al*. (2016) in pomegranate.

The shoot length was maximum (13.76 cm) in cuttings treated with T11 (IBA @ 250 ppm + NAA @ 250 ppm). The shoot length was the least in the control (9.02 cm). The increased shoot length obtained in cuttings treated with growth regulators due to the increase in cell division and cell elongation because of the actions of auxins. Thses findings are in accordance with the results reported by Ramkete *et al*. (2016) and Munde *et al*. (2016) in pomegranate.

The girth of the shoot per cutting was maximum (0.22 g) in cuttings treated with T11 (IBA @ 250 ppm + NAA @ 250 ppm). The girth of the shoot per cutting was the least in the control (0.10 g). These findings were similar to Singh *et al*. (2013) in *citrus lemon*, Singh *et al*. (2014) in mulberry, Kaur (2015) in peach and Kaur and Kaur (2017) in fig respect to length and diameter of sprouts per cuttings.

The maximum survival percentage in the rooting media was noticed in the cuttings treated with T11 IBA @ 500 ppm + NAA @ 500 ppm (84.85%). The survival percentage of rooted cuttings was least in control (36.40%). This might be due to increased length, maximum number of primary roots, which probably absorb more nutrients and water from the soil under low transpiration losses. The effect of auxins might be due to the slow translocation property or slow destruction of auxins by auxin destroying enzyme system as reported by Debnath and Maiti (1990).

Finally, it could be concluded that the higher rooting of cuttings and maximum survival percentage of cuttings could be obtained by application of IBA @ 500 ppm and NAA @ 500 ppm – 5 minutes in guava.

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EFFECT OF ORGANIC MANURES ON THE NUTRIENT UPTAKE OF *Plectranthus vettiveroides*

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Abstract

The experiment on "Effect of organic manures on nutrient uptake of Plectranthus vettiveroides" was carried out in Kollidam during 2020-2022. A field trial was conducted in a Randomized Block Design with nine treatments in three replications. The treatment consisted of organic manures at farmyard manure, vermicompost, neem cake and groundnut cake.

Introduction

Medicinal plants encompass a huge number of plant species that are used in homeopathy and various Indian systems of medicines such as folk medicine, Ayurveda, Siddha, and Unani. About 4500 species are used in different folk medicines, 1700 in Ayurveda, 1000 in Siddha, 700 in Unani and 500 in Homeopathy. The demand for the products obtained from these plants such as phytochemicals, steroids, alkaloids, and biologically active compounds etc., is increasing in national and international market. A medicinal plant can be used for therapeutic purposes and used as precursor for the synthesis of useful drugs. Several medicinal plants have been used in traditional medicine for many years (Abayomi *et al*., 2013). India is the second largest exporter of medicinal plants next to china. The area under medicinal plants has increased over the years with the annual growth rate of 1.12 % per annum. *Plectranthus vettiveroides* commonly known as Hrivera, formerly referred as Coleus vettiveroides is a perennial herb belonging to the family Lamiaceae. Its common name known from various languages following different names Iruveli in Malayalam, Vettiver and Kuruver in Tamil, Kuriveru and Vettiveru in Telugu, Lavanchi and Muchivala in Kannnada, Valak in Hindi and Valakam and Hriberam and Hribera in Sanskrit. There are no systematic studies in *Plectranthus vettiveroides* for its commercial cultivation through organic sources. There is great demand for its roots in Indian system of Medicine (ISM) such as Ayurvedic, Siddha and Unani for traditional medicinal preparations. Limited reports are available on propagation practices in *Plectranthus vettiveroides*. Among agro techniques, organic manures play an important role because of the advantage of providing organic source of nutrients for improving biomass and preserving quality of plant products. Hence, organic manures as source is very essential for both boosting the sustainable production of medicinal and aromatic plants. Considering above points, the present study was proposed with the objective to study the nutrient uptake of *Plectranthus vettiveroides* by influencing of organic manures.

Materials and Methods

An experiment was carried out at farmer field Kollidam, Sirkazhi Taluk, Nagapattinam District. The present study was entitled to "Effect of organic manures on nutrient uptake of *Plectranthus vettiveroides*" was conducted during the year 2020 – 2022. The treatments consist of organic manures at farmyard manure (FYM), vermincompost (VC), neem cake (NC) and groundnut cake (GC). The experiment was laid out in randomized block design with 9 treatments and three replications. The different treatment combinations *viz*., T_1-100 percent RDF, T_2-FYM @12.5 t ha^{-1}+ GC @ 200kg ha^{-1}, T_3- VC @5 t ha^{-1}+ GC @ 200 kg ha $^{-1}$, T_4- FYM @12.5 t ha^{-1} + NC @ 200

kg ha^{-1}, T_5- VC @ 5 t ha^{-1} + NC @ 200 kg ha^{-1}, T_6- FYM @ 12.5 t ha^{-1}+ GC @ 200 kg ha^{-1} + Azospirillum @ 2 kg ha^{-1}, T_7- VC @ 5 t ha^{-1} + GC @ 200 kg ha^{-1} + *Azospirillum* @ 2 kg ha^{-1}, T_8- FYM @ 12.5 t ha^{-1} + NC @ 200 kg ha^{-1}+ *Azospirillum* @ 2 kg ha^{-1} and T_9- VC @ 5 t ha^{-1}+ NC @200 kg ha^{-1}+ *Azospirillum* @ 2 kg ha^{-1}. Plant samples were oven dried and ground in a wiley mill containing stainless steel blades and passed through 0.05 mm sieve and the powder was used for further analysis. Nitrogen was estimated by microkjeldahl methods as outline by Humphries (1956). Phosphorous was determined by vanadomolybdate phosphoric acid yellow colour method in nitric acid system (Jackson, 1973). Potassium was determined by flame photometer method (Jackson, 1973) and the nutrient uptake (NPK) was expressed in kg ha $^{-1}$. Soil sample were collected from each treatment at a depth of 15-30 cm after completion of the harvest of the crop. The samples were dried under shade, powdered, and sieved through 2mm sieve. The samples were analysis for available N, P and k contents. The available nitrogen content in each treatment was estimated by alkaline permanganate method suggested by Subbiah and Asija (1956). The available phosphorous content was estimated by ascorbic acid modification of the molybdate blue method as suggested by Olsen *et al*. (1954). The available potassium in each treatment was estimated by flame photometer method suggest by Stanford and English (1949) and expressed in kg ha $^{-1}$. The observed data was analysed by using statistical method of Panse and Sukhatme (1985).

Result and Discussion

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left-over material from roughages or fodder feed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 per cent P_2O_5 and 0.5 per cent K_2O (Kumar and Chaudhary, 2018). Vermicompost is one of the superior nutrient-rich materials among the other organic amendments. According to (Anonymous, 2008) Groundnut cake is one of the important organic sources for plant nutrients. It contains nitrogen, phosphorus, potassium along with a large percentage of organic matter. In addition, it is quick acting organic manure. Neem cake is the by-product obtained in the process of cold pressing of neem tree fruits and kernels and the solvent extraction process for neem oil. The uptake of nitrogen, phosphorus and posttasium was significantly influenced by application of organic nutrient (Table 1.). After harvest, the maximum uptake of total NPK ha^{-1} was recorded on the plants treated with T7 (VC @ 5 t ha^{-1} + GC @ 200 kg ha^{-1} + Azospirillum @ 2 kg ha^{-1}) is 88.5, 17.4 &125.7 kg ha^{-1} respectively and the lowest amount of NPK uptake by plant ha^{-1} was registered in T4 (FYM @ 12.5 t ha^{-1} + NC @ 200 kg ha^{-1}) with values of 47.8, 6.75 &76.4 kg ha^{-1} respectively. The available NPK of the soil ha^{-1} was significantly increased due to the supply of T7 (VC @ 5 t ha^{-1} + GC @ 200 kg ha^{-1} + *Azospirillum* @ 2 kg ha^{-1}) registered with the values of 186.54, 15.65 & 254.32 kg ha^{-1} and least amount of NPK was found in T_4 (FYM @12.5 t ha^{-1} + NC @ 200 kg ha^{-1}) is 162.43, 11.13 &210.54 kg ha^{-1} respectively. The maximum nutrient uptake by the plants and NPK content in postharvest soil was recorded with application of (T_7) vermicompost @ 5 t ha^{-1} + ground cake @ 200 kg ha^{-1} + *Azospirillum* @ 2 kg ha^{-1}. These results are in accordance with the findings of Smitha*et al*. (2019) and HosseinAyyobi*et al*. (2013). This may be due to slow mineralization of the N from manure and compost compared with fertilizer, a higher application of N through organic sources and a sustained availability to the crop as evidenced by a higher herb and oil yield in compost and FYM treated soils (Anwar *et al*., 2005).

Conclusion

Based on the observation recorded, it could be concluded that among the various treatments of organic manures on *Plectranthusvettiveroides*, the maximum nutrient uptake and NPK content in postharvest soil was recorded with application of (T7) vermicompost @ 5 t ha^{-1} + ground cake @ 200 kg ha^{-1} + Azospirillum @ 2 kg ha^{-1}. The combined use offarmyard manure, vermincompost, neem cake and groundnut cake, recorded significantly higher nutrient uptake and available soil NPK content in *Plectranthusvettiveroides*due to increased soil fertility through proper organic nutrient management.

Table 1. Effect of organic manure on the nutrient uptake and available soil nutrientsin *Plectranthusvettiveroides*

Treatments	Nutrient uptake (kg ha^{-1})			Available soil nutrient (kg ha^{-1})		
	N	P	K	N	P	K
T_1	83.5	16.8	115.4	183.32	14.98	248.65
T_2	60.3	10.8	88.3	168.98	11.87	223.54
T_3	66.8	11.2	93.6	172.32	12.11	227.98
T_4	47.8	6.75	76.4	162.43	11.13	210.54
T_5	54.7	8.5	84.5	165.43	11.49	217.86
T_6	76.4	15.6	111.2	179.54	13.67	243.65
T_7	88.5	17.4	125.7	186.54	15.65	254.32
T_8	70.2	13.2	98.6	175.34	12.28	234.54
T_9	73.7	14.4	102.6	177.97	12.87	238.65
S.Ed	0.91	0.17	1.29	2.15	0.16	2.88
CD(P=0.05)	1.82	0.34	2.5	4.30	0.32	5.76

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EFFECT OF PGPR FROM SEWAGE ECOSYSTEM ENRICHED VERMICOMPOSTING ON GROWTH AND DEVELOPMENT OF CHILLI

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Abstract

In the present investigation, an attempt was made to study the effect of vermicompost enriched with certain PGPR isolates from sewage ecosystem of Annamalai University Experimental farm on growth and development of Chilli under pot culture conditions. The results clearly revealed that enrichment of efficient PGPR isolates PDAZS – 5 (Azospirillum lipoferum); PDBA – 1 (Bacillus megaterium) and PDPS - 3 (Pseudomonas fluorescens) with vermicompost as individual and consortium significantly increased the growth, yield and nutritional parameters of Chilli var. Co – 2.

Key words: *PGPR; Sewage ecosystem; Chilli*

Introduction

The utilization of sewage sludge in agriculture is gaining popularity of waste disposal. Raw sewage contains high amount of organic and inorganic substances, N, P, and other plant growth promoting substances it helps to increasing the plant growth. Irrigation with wastewater can have a number of benefits and environmental applications if appropriately planned, implemented, and managed (Bixio *et al*., 2006).

Plant growth promoting rhizobacteria (PGPR) has acquired natural components to replace the chemical fertilizers used in agriculture, horticulture, silviculture, and even for environmental clean-up strategies.

Various research data on PGPR reveal that its effects on plant physiology and developments are over stated in biosynthesis and biofertilizers of pathogen inducing a systemic resistance. Bacteria naturally occurring in soil to enhance the growth of PGPR and also colonize the plant roots which are beneficial to the plant growth. Inoculation of certain PGPR strains at early stage of development directly to the crop plants increasing the biomass production.

Vermicompost is a nutrient-rich, peat-like substances characterized by high porosity, high water-holding capacity, and low C:N ratio (Domínguez 2004). When used as an amendment for soil or other plant growth media, vermicompost stimulates growth, seed germination and development, flowering, and fruit production of a variety of plant species (Lazcano and Domínguez, 2011; Muthuselvam, 2010). Vermicompost improves the physical, chemical, and biological properties of the soil as well contributes to organic enrichment. Most of these investigations have confirmed that vermicompost usually has significant beneficial effects on plant growth. However, there have been very few experimental investigations exploring effects of vermicompost applications in chilli.

Capsicum annum L. is the most consumed vegetable that is well adjusted and therefore often produced under greenhouse conditions. It is an important vegetable crop grown in almost all parts of the tropical and subtropical regions in the world. Keeping in view of above criteria the study was conducted to find the effect of enriched vermicompost on growth and development of chilli.

The PGPR isolates including *Azospirillum,* Phosphobacteria and *Pseudomonas* were isolated from sewage ecosystem of Annamalai University experimental form by following the standard microbiology protocols. The PGPR isolates were characterized and screened for their efficiency for vermicompost enrichment.

The enrichment of vermicompost with efficient PGPR isolates were carried out by blending 2 kg of 45 days old respective PGPR inoculated vermicompost with 10 kg vermicompost. Enrichment processes were carried out for 60 days by maintaining moisture content between 40 and 45 % levels.

A pot culture study was conducted with efficient PGPR isolates *viz., A. lipoferum* PDAZS-5, *B. megaterium* PDBA-1 and *P. fluorescens* PDPS - 3 as individual and consortium enriched vermicompost on growth, yield and quality attributes of Chilli var. Co2 along with vermicompost, 100 % recommended dose of fertilizer (RDF) and absolute control as completely randomized block design with triplicates and with the following treatments.

T_1– Control

T_2 - 100 % RDF

T_3 - Vermicompost 100 % (135:62.5:50 kg N:P:K ha^{-1})

T_4 - *A. lipoferum* PDAZS- 5 enriched vermicompost

T_5 -*B. megaterium* PDBA- 1enriched vermicompost

T_6 - *P. fluorescens* PDPS-3 enriched vermicompost

T_7 - PGPR consortium (*A. lipoferum* PDAZS - 5 + *B. megaterium* PDBA - 1 + *P. fluorescens* PDPS - 3) enriched vermicompost

The plant growth parameters (Germination % and Vigour index, plant height and dry matter production); yield parameters (Fruit yield, Number of fruits and Fruit weight) and biochemical characters (total chlorophyll content and Capsaicin content) were recorded with standard protocols.

Results and Discussion

Effect on germination percentage and vigour index of chilli var Co 2

Among the seven different treatments, the treatment T_7 (PGPR isolates enriched vermicompost) was recorded maximum germination percentage and vigour index 91.02% and 1477.25 respectively. The treatment was followed by (T_2 – 100% NPK) 90.24% and 1238.8 and the least germination percentage was noticed (T_1) control 54.98% with vigor index of 629.6 (Table - 1).

Table – 1. Effect on germination percentage and vigour index of chilli var Co 2

Treatment	Germination (%)	Vigour Index	Root length	Shoot length
T_1	54.98	629.6	5.33	6.12
T_2	90.24	1238.8	6.63	7.10
T_3	84.90	1043.4	6.42	5.87
T_4	63.34	889.9	7.43	6.62
T_5	73.74	1022.0	6.98	6.88
T_6	85.33	1296.16	7.61	7.58
T_7	91.02	1477.25	7.90	8.33
S.Ed	4.4136	-	0.3945	0.7029
CD (P=0.05)	9.4672	-	0.8462	1.5077

Effect on Plant height

The least plant height was recorded in T_1 (control) with 34.03, 46.34, 65.37, 78.32 and 86.78 cm on 30, 60, 90 120 DAS and at harvest time respectively. It was followed by RDF (T_2 - 100 % NPK) with 7.95%, 5.50%, 12.26%, 9.11%, 5.17% increase over T_1 (control). The treatment (T_3) received 100% vermicompost application with 9.99%, 2.89%, 4.34%, 7.80%, 8.07% increase over T_1 (control).The parameters were significantly improved by the application of enriched vermicompost with individual PGPR isolates (T_4, T_5 and T_6). At the time of harvest stage (150 days), the plant height of 105.40 cm (16.02 % increase over T_2), 92.59 cm (1.44 % increase over T_2) and 96.42 cm (5.64 % increase over T_2) were recorded by T_4, T_6 and T_5 respectively were observed (Fig. 1.).

The efficient PGPR isolates consortium enriched vermicompost treatment (T_7) performed better than all other treatments. Further, it was able to produce statistically significant values than individual PGPR enriched vermicompost treatments (T_4, T_5 and T_6). The treatment was showed 22.91%, 20.06%, 18.57%, 15.34% and 26.72 % increase over T_2 (100 % inorganics) and 21.39%, 23.11%, 27.57%, 16.74% and 23.31 % increase over T_3 (vermicompost) on 30, 60, 90, 120 and 150 DAS respectively.

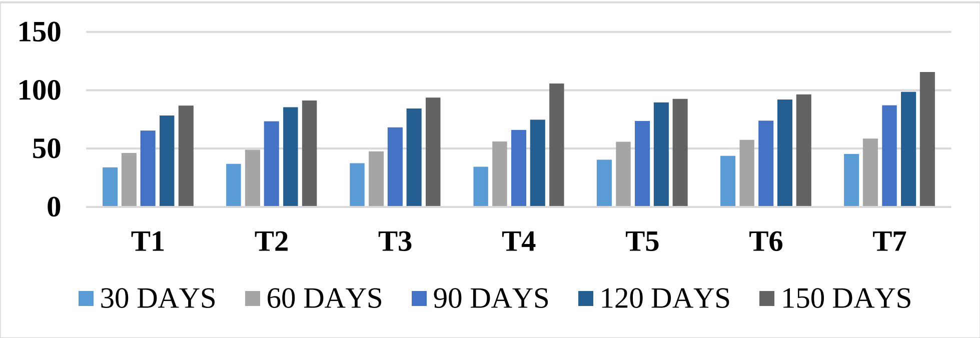

Fig. 1. Effect on plant height on Chilli Var Co 2

Effect on dry matter production

The highest dry matter production of 4.18 g plant^{-1} was recorded in T_7 (PGPR consortium enriched vermicompost) treatment at harvest stage. It was able to produce 9.71 % increase dry matter than T_2 (100 % RDF) treatment. The treatment was followed by individual PGPR isolates enriched vermicompost treatments with 4.13 g plant^{-1} (T_4 - *A. lipoferum* PDAZS - 5), 3.97 g plant^{-1} (T_6 - *P. fluorescens* PDPS - 3) and 3.93 g plant^{-1} (*B. megaterium* PDBA - 1) which were 8.39 %, 4.19 % and 3.14 % increase over 100 % recommended dose of inorganics (T_2) treatment. Vermicompost application @ 2.5 t ac^{-1} (T_3) significantly increased 1.04% dry matter production of plants than RDF (T_2) treatment at harvest stage.

Table – 2. Effect on Dry matter Production.

Treatment	Dry matter production (g plant^{-1})				
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
T_1	0.74	2.33	2.86	3.18	3.75
T_2	1.50	2.06	2.94	3.30	3.81
T_3	1.62	2.03	2.84	3.09	3.85
T_4	1.94	2.09	2.86	3.14	4.13

T_5	2.02	2.10	2.93	3.26	3.93
T_6	2.11	2.23	2.91	3.36	3.97
T_7	2.23	2.64	3.14	3.36	4.18
S. Ed	0.1926	0.1715	0.0982	0.1113	0.1238
CD (P=0.05)	0.4132	0.3679	0.2107	0.2387	0.2656

Effect on Number of fruits, Fruit weight and Fruit yield

It was observed that the number of fruits, fruit weight and fruit yield of chilli was significantly increased by all the treatments over control. It was observed that the combined inoculation of treatment T_7 (*A. lipoferum PDAZS-5 + B. megaterium PDBA-1 +P. fluorescens PDPS-3)* was observed to be the best than other treatments under pot culture study. The treatment recorded maximum number of fruits of (35 Plant^{-1}), fruit weight (7.64 plant^{-1}) and fruit yield (215.43 plant^{-1}).

Among the individual PGPR enriched vermicompost treatments, the inoculation of *pseudomonas* (T_6) was found to be best and recorded number of fruits of (33 Plant^{-1}), fruit weight (6.32 Plant^{-1}) and fruit yield (155.34 Plant^{-1}) was recorded. The minimum number of fruits, fruit weight, and fruit yield were recorded in T_1 (Control) with 17 Plant$^{-1,}$ 4.70 Plant^{-1} and 82.62 Plant^{-1}as respective values.

Table – 4. Effect on number of fruits, fruit weight and fruit yield

Treatment	**No of fruits (plant^{-1})**	**Fruit weight (g plant^{-1})**	**Fruit yield (plant^{-1})**
T_1	17	4.70	82.62
T_2	28	5.05	86.44
T_3	26	5.49	98.88
T_4	30	5.56	118.82
T_5	32	6.10	129.70
T_6	33	6.32	155.34
T_7	35	7.64	215.43
S. Ed	3.0929	0.4851	-
CD (P=0.05)	6.7390	1.0405	-

Effect on Chlorophyll and Capsaicin contents

According to this study, chlorophyll content has negative correlation with maturity of were observed in Table - 4. The control (T_1) treatment recorded less chlorophyll content of 1.90 mg g^{-1}, of total chlorophyll at harvest time. It was followed by 100% RDF (T_2) treatment with 2.01 mg g^{-1}. Application of vermicompost alone (T_3) and PGPR enriched vermicompost treatments (T_4, T_5, T_6 and T_7) significantly increased the total chlorophyll content in chilli leaves than the inorganic fertilizers (T_2) and control (T_1) treatments. The treatment T_4 (*A. lipoferum* PDAZS-5 enriched vermicompost) recorded 2.05 mg g^{-1}; T_5 (*B. megaterium* PDPA - 1 enriched vermicompost) with 2.08 mg g^{-1} and T_6 (*P. fluorescens* PDPS - 3 enriched vermicompost) with 2.15 were observed. Among the PGPR enriched vermicompost treatments, T_7 (PGPR consortium enriched vermicompost) recorded more chlorophyll contents *viz.*, 2.28 mg g^{-1} (13.43 % increased over T_2) were observed.

Application of vermicompost (T_3) and enriched vermicompost treatments (T_4, T_5, T_6 and T_7) significantly increased the total capscicin content in chilli fruit than the inorganic fertilizers (T_2) and control (T_1) treatments. The control (T_1) treatment recorded very poor capscicin content of 0.58 %. It was followed by 100% inorganics (T_2) treatment with 0.60 %.Whereas, the application of 100% vermicompost @ 2.5t ac^{-1} (T_3) resulted 0.63 (5 % increase than control), was observed. Among the PGPR enriched vermicompost treatments, T_7 (PGPR consortium enriched vermicompost) recorded more capscicin contents of 0.63(%) was observed.The individual PGPR enriched vermicompost treatments recorded the capscicin content of 0.56% in T_4 (*A. lipoferum* PDAZS-5 enriched vermicompost); 0.58 % in T_6 (*P. fluorescens* PDPS-3 enriched vermicompost) and 0.60 % in T_5 (*B. megaterium* PDBA – 1 enriched vermicompost).

Table – 5. Effect on Chlorophyll and Capsaicin contents

Treatment	**Chlorophyll content (mg g^{-1})**	**Capsaicin content (%)**
T_1	1.90	0.58
T_2	2.01	0.60
T_3	2.09	0.63
T_4	2.05	0.56
T_5	2.08	0.58
T_6	2.15	0.60
T_7	2.28	0.63
S. Ed	0.1782	0.0998
CD (P=0.05)	0.3821	0.2142

Conclusion

The enhancement of nutrient status by enriching vermicompost by different groups of microorganisms were already reported by many researchers *viz.*, Kaushik *et al.* (2008); Yadav *et al.* (2009); Muthuselvam, (2010); Mahanta *et al.* (2012).

The beneficial aspects of different genera of PGPR inoculation in variety of crops were already reported (Chelius and Triplett, 2000a; Dong *et al*., 2001; Paluset *al*., 1996; Gao *et al*., 2004) were extensively studied earlier by several scientists. The possible mechanisms involved in PGPR may be due to the several mechanisms like biological nitrogen fixation, increasing the availability of nutrients in the rhizosphere, inducing increases in root surface area, enhancing other beneficial symbioses of the host and combination of modes of action.

Similarly, the beneficial role of vermicompost in plant growth and development of many crops have been reported earlier (Ansari, 2011, Vasanthi *et al.*, 2011; Gomez-Brandona *et al.*, 2011; Moghadam *et al.*, 2012; Muthuselvam, 2010; Moghadam *et al.*, 2012; Tringovska and Dintcheva 2012). The different mechanisms involved in growth promoting activities of vermicompost may be due to the facts like more nutrient contents in the available forms, growth promoting substances and associated beneficial microorganisms.

Hence, integration of both vermicompost and the beneficial PGPR may render the synergistic effect on crop growth and development. Further, the bacterial isolates were isolated from sewage ecosystem may be a sustainable utilization of hazardous environment into a beneficial one.

The results of the present investigation clearly revealed that all the growth parameters (germination percentage, vigour index, plant height, dry matter production, total chlorophyll content, yield parameters (number of fruits, fruit weight and fruit yield) and the capsaicin content were significantly improved in the consortium treatment T_7 (Vermicompost + *A. lipoferum* PDAZS – 5; *B. megaterium* PDBA - 1 and *P. fluorescens* PDPS - 3) followed by individual PGPR enriched vermicompost, RDF and control treatment.

From the above study, it was concluded that enrichment of efficient PGPR isolates *A. lipoferum* PDAZS – 5; *B. megaterium* PDBA - 1 and *P. fluorescens* PDPS - 3 isolated from the sewage ecosystem of Annamalai University experimental farm with vermicompost as individual and consortium significantly increased the growth, yield and nutritional parameters of Chilli var. Co - 2.

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INFLUENCE OF FOLIAR APPLICATION OF NANO NUTRIENTS ON GROWTH OF CAPSICUM *(Capsicum annuum L. var. grossum)*

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Abstract

Vegetables are the prime source of vitamins and minerals. As the population increases there is also increase in demand for nutritional vegetables, but in the conventional method of horticulture the production and productivity are considerably less. Thus, to increase the productivity and to feed the over burgeoning population there is a need for novel fertilizers such as Nano fertilizers. An experiment was hence conducted in Chinapettai village, Panruti to investigate the Influence of foliar application of Nano nutrientson growth of Capsicum. The experiment was carried out in RBD design (Randomized block design) with three replications and thirteen treatments. Results showed that the treatment with 100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu followed by 25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu and 50% RDF -N : RDF (100% P:K) + 50% Nano N + Nano Zn + Nano Cu recorded maximum growth parameters. In contrast 50% RDF -N : 100% RDF (P:K) + 50% Nano Nshowed increase in growth than the control 100% RDF(N:P:K)(250:150:150kg/ha) to conclude that Nano nitrogen could have compensated the 50% urea recommendation in conventional fertilizer and also had enhanced effect than control.

Introduction

Vegetables are economic engines for productive, profitable agriculture economics. Its production provides a promising economic opportunity for reducing rural poverty and unemployment in developing countries and is a key component of farm diversification strategies (Schreinemachers *et al*., 2018). India is the second largest producer of vegetables in the world (surpassed only by china). Vegetables are humans most accessible sources of vitamins and minerals for wholeness. This era trapper the need of vegetable production for economic and nutritional security and to achieve the millennium development goals in a timely fashion.

The genus Capsicum belongs to the family Solanaceae which is grown in several parts of the world and believed to be native of south America (Shoemaker and Teskey,1995). Today, Capsicums are one of the preponderantly used of all natural remedies. Modern Mayan pharmacopoeia divulged that the tissues of capsicum are encompassed in several herbal remedies for a variety of malady of probable microbial origin (Cichewicz and Thorpe,1996). Post-operative pain in mastectomy patients and ‘phantom limb’ pain in amputees are reduced using a cream containing Capsaicin. Itching in dialysis patients and cluster headaches are also reduced by long term use of such creams (Carmichael, 1991).

Bell pepper is rich in Vitamin A (8493 IU), Vitamin C (283 mg) and minerals like Calcium (13.4 mg), Magnesium (14.9 mg), Phosphorus (28.3 mg) and Potassium (263.7 mg) per100 g^{-1} fresh weight. Capsicum is a cool season crop, but it can be grown round the year using protected structures where temperature and relative humidity (RH) can be manipulated. This crop requires a day temperature of 25-30^{0}C and night temperature of 18-20^{0}C with relative humidity of 50-60%. If temperature exceeds 35^{0}C or falls below 12^{0}C, fruit setting is affected. Bell pepper has attained a status of high value crop in India. Its rich content of ascorbic acid and other vitamins and minerals

coupled with pleasant flavor and its delicacy in Indian cuisine attained a pride place among other vegetables. They are also frequently used both chopped and raw in salads, or cooked in stir-fries or other mixed dishes. They can be preserved in the form of a jam or by drying, pickling, or freezing. Dried peppers may be reconstituted whole, or processed into flakes or powders. Pickled or marinated peppers are frequently added to sandwiches or salads. Frozen peppers are used in stews, soups, and salsas. Extracts can be made and incorporated into hot sauces.

However, India has many growing concerns. In the Indian economy the horticultural contribution to GDP has steadily declined while achieving enough food production, India still reports for a one fourth of the world's hungry people and home to over million undernourished people. Indian horticulture feels the pain of fatigue of green revolution, the yield in many crops have been stagnated due to over use of fertilizers. Also, low nutrient use efficiency due to leaching, declining soil organic matter, multi nutrient deficiencies, shrinking arable land, shortage of labor are results of evacuation of people from farming (Godfray *et al.*, 2014)

The nutrient use efficiency of Nitrogen have reminded constant leaving a major amount of fertilizers to pile up in the soil or aquatic system that cause eutrophication, Thus to address these problems, the Nano based nutrients grabs the position which have a characteristic of small size and large surface area to volume ratio,precisely detect and deliver correct quantity of nutrients required by the crop in suitable proportion that promote productivity and also ensure environmental safety (Carpenter *et al*.,1998).

When minimized to the nanoscale, these nutrients show some characteristics that differ from the presence of the nutrients in the macro scale, allowing unique applications (Naderi and Danesh-Shahraki, 2013). Compared with chemical fertilizers, Nano-fertilizers has larger specific surface area, which makes nutrients more easily absorbed by plants, which significantly improves its fertilizer use efficiency and has significant economic benefits. The application of Nano-fertilizer can improve the physical and chemical properties of soil and improve the ability of water and fertilizer conservation (Yu ZQ, 2014). With the above background, the present study is initiated to know the Influence of foliar application of Nano nutrients (Nano N, Nano Zn & Nano Cu) on growth of capsicum with the objective

To study the effect of Nano N, Zn and Cu on crop growth.

Materials and Methods

The current studies on Influence of foliar application of Nano Nutrients on growth of Capsicum were carried out in a farmer's field at Chinnapettai village in Panruti, Cuddalore district of Tamilnadu during 2019-2020. The details of materials used and the methods adopted during investigation are presented below

Geographical Location of the Experimental Field

The experimental site is geographically situated at 11°.49' North latitude and 76.97° East longitude at an average elevation of 23 meters above mean sea level in the Cuddalore district of Tamilnadu.

Weather and Climate

The weather of Panruti is moderately warm with hot summer. The maximum mean temperature of the location ranges from 20.6°C to 34. 4°C.while the minimum mean temperature ranges from 20°C to 27°C. The average Precipitation is about 1030.35 mm annually, of which 547.14 mm is received during North East monsoon (Oct-Dec), 340.04 mm is received during South West monsoon (June-Sept) and 143 mm is received as summer shower.

Experimental Details

Location	:	Chinnapettai, Panruti.
Number of Treatments	:	13
Number of Replication	:	3
Plot Size	:	4 X 5 m^2
Total number of plants	:	2222 plants
Total number of plants per plot (20 m^2)	:	57 plants
Area	:	18 cents
Spacing	:	90X60X60 cm (Paired row system)
Variety	:	Priyanka 55

Treatment Details

SYMBOL	TREATMENTS
T_1	100% RDF(N:P:K)(250:150:150kg/ha)
T_2	25% RDF -N : 100% RDF (P:K) + 75% Nano N
T_3	50% RDF -N : 100% RDF (P:K) + 50% Nano N
T_4	75% RDF -N : 100% RDF (P:K) + 25% Nano N
T_5	100% RDF (P:K) + 100% Nano N
T_6	100% RDF (N:P:K) + Nano Zn
T_7	100% RDF (N:P:K) + Nano Cu
T_8	100% RDF (N:P:K) + Nano Zn + Nano Cu
T_9	100% RDF (P:K) + 100% Nano N + Nano Zn
T_{10}	100% RDF (P:K) + 100% Nano N + Nano Cu
T_{11}	100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu
T_{12}	25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu
T_{13}	50% RDF -N : RDF (100% P:K) + 50% Nano N + Nano Zn + Nano Cu

Crop and Variety

Bell pepper var. Priyanka 55 produced by United Genetics India Pvt. Ltd. was used in the study.

Source of Nano Nutrients

The Nano Nutrients such as Nano Nitrogen, Nano Zinc and Nano Copper used in this Study Were Obtained from IFFCO (Indian Farmers Fertiliser Cooperative Limited, New Delhi).

Methods

Crop management

Preparation of nursery and sowing of seeds

Seeds of Capsicum var. Priyanka 55 was sown in the protrays (98 cells) at one seed per cell filled with coir pith. The seeded protrays were maintained in a HDPE green 50% shade net. Provision was also made to pull polythene sheet over the pro-trays in the event of rainfall by way of making low tunnel structure made of 3/4" LDPE pipes and 400-gauge UV stabilized polyethylene sheet.

Preparation of main field and planting

The main field was ploughed three to four times until fine tilth, after the first tilth Farm yard manure (1.5t) were applied. Paired rows were formed and drips was laid out and the spacing adopted was 90 x 60 x 60 cm in paired row system. 100-micron polythene sheets were used for mulching.

Transplanting

Transplanting was done in evening and watered immediately after transplanting. About 35 days old seedlings were used for transplanting. Gap filling was done 10 days after transplanting with existing seedling to maintain the ideal plant population.

Irrigation

Drip irrigation was used for irrigation with a capacity of two litres per hour. Thus, each plant received about 310ml per irrigation for 10 minutes. Life irrigation was given three days after transplanting and subsequent irrigation was done for every three days.

Fertilizer Application

The recommended dose of phosphorus and potassium were applied at basal (150:150 kg /ha) as SSP (Single super phosphate) and MOP (Murate of potash) at 1.875 kg and 500 g per plot. Nitrogen was applied in the form of urea as per the treatments as 100 % ,75% and 50 % .500 g of urea was applied as basal dose to all the treatment except treatments (deprived of Nitrogen) and subsequent application of Nitrogen was given at 30th, 60th and 90th day after transplanting to 100% RDN: - treatments. For 75% RDN: - treatments nitrogen was given at 30th and 60th days after transplanting alone and for 50% RDN: - treatments nitrogen was given at 30th days after transplanting alone as top dressing.

Application of Nano Fertilizers

Application of Nano Nutrients such as Nano Nitrogen, Nano Zinc and Nano Copper was done by Foliar application at three stages (Vegetative stage, flowering stage and fruiting stage). The Foliar application of Nano nutrients was given as per the treatments at the rate of 4ml per litre with power sprayer.

Training

The plants were trained by jute ropes tied to the horizontal gauge wire in the top. Training was done at 4 weeks after transplanting.

Harvesting

Harvesting was done 60 days after transplanting and when fruits show waxy coating and ideal size. Harvesting was done at 10 days’ interval. The fruits harvested from tagged plants were used for taking yield parameters.

Observations

In each treatment, five randomly selected plants were tagged for recording the observations on growth parameters**.**

Growth Parameter

Plant height

The plant height was measured from the base of the plant at ground level to the tip of main stem on 30th, 60th and 90th day after transplanting and expressed in centimetres (cm).

Number of Branches

The number of branches arising from the main branch was recorded on the final harvest of randomly tagged five plants on each treatment plot and expressed in numbers.

Days to 50% Flowering

The days taken from planting to 50% flowering was recorded in each plot and then the mean value was expressed in days.

Experimental Results

Field experiment was carried out in farmer field at Chinnapettai, Panruti during 2019-2020, to study the Influence of foliar application of Nano nutrients (N, Zn and Cu) on growth of Capsicum. The influence of treatments was studied in terms of morphological and yield components. All the components were recorded in between 30 and 120 days after transplanting and the yield characters were recorded at the time of harvest. The data were statistically analyzed and the details of the experimental results are presented below.

Growth parameters

Plant height

The data featured in table 1 on plant height at 45th,75th DAT and at final harvest brought in view a significant variation in plant height. Among the treatments, the utmost plant height was recorded in T_{11} - 100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu(57.4 cm) followed by T_{12} -25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu(56.2 cm) and T_{13} - 25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu(55.4cm) followed by T_9- 100% RDF (P:K) + 100% Nano N + Nano Zn(55.3cm)were recorded on par at 45th days after transplanting followed by T_{10} -100% RDF (P:K) + 100% Nano N + Nano Cu (54.8cm), T_5-100% RDF (P:K) + 100% Nano N (54.6cm) and T_2 - 25% RDF -N : 100% RDF (P:K) + 75% Nano N (54.3 cm) which is also on par . Treatment T_5 - 100% RDF (P:K) + 100% Nano N and T_{11} - 100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu recorded the plant height of 54.6 cm and 57.4 cm which is greater than T_1 - 100% RDF(N:P:K)(250:150:150kg/ha) (47.6cm). The lowest plant height was recorded in T_1 - 100% RDF(N:P:K)(250:150:150kg/ha) (47.6cm). The same trend was observed on 75TH DAT and at final harvest.

Number of branches per plant

The data on Number of branches is presented in table 2 revealed that there is a significant variation in Nano nutrients treatment plots compared to the control (RDF)**.**Among the various treatments tested, T_{11} - 100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu (15.1) followed byT_{13} - 50% RDF -N : RDF (100% P:K) + 50% Nano N + Nano Zn + Nano Cu (15.0) followed by T_{12} - 75% RDF -N : RDF (100% P:K) + 25% Nano N + Nano Zn + Nano Cu (14.9) which recorded on par values showed the utmost number of branches followed by T_9 -100% RDF (P:K) + 100% Nano N + Nano Zn (14.8), T_{10} -100% RDF (P:K) + 100% Nano N + Nano Cu (14.7),T_5-100% RDF (P:K) + 100% Nano N (14.7) and T_2 - 25% RDF -N : 100% RDF (P:K) + 75% Nano N (14.6) which

is also on par . The lowest number of branches was recorded in T_1 - 100% RDF(N:P:K)(250:150:150kg/ha)(11.6)

Table 1: Influence of foliar application of Nano N, Zn and Cu on plant height at 45th day ,75thday and at final harvest in Capsicum.

T.No	**Treatments**	**Plant height(cm)**		
		45DAT	**65DAT**	**At Harvest**
T_1	100% RDF(N:P:K)(250:150:150kg/ha)	47.6	57.7	83.5
T_2	25% RDF -N : 100% RDF (P:K) + 75% Nano N	54.3	72.5	110.4
T_3	50% RDF -N : 100% RDF (P:K) + 50% Nano N	53.9	70.8	110.1
T_4	75% RDF -N : 100% RDF (P:K) + 25% Nano N	53.3	70.2	108.0
T_5	100% RDF (P:K) + 100% Nano N	54.6	72.8	110.6
T_6	100% RDF (N:P:K) + Nano Zn	50.0	64.0	96.0
T_7	100% RDF (N:P:K) + Nano Cu	50.5	62.7	97.5
T_8	100% RDF (N:P:K) + Nano Zn + Nano Cu	51.1	65.5	98.8
T_9	100% RDF (P:K) + 100% Nano N + Nano Zn	55.3	73.1	111.3
T_{10}	100% RDF (P:K) + 100% Nano N + Nano Cu	54.8	71.6	111.5
T_{11}	100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu	57.4	74.6	112.7
T_{12}	25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu	56.2	74.4	112.4
T_{13}	50% RDF -N : RDF (100% P:K) + 50% Nano N + Nano Zn + Nano Cu	55.4	73.7	111.7
	S.ED	**1.3**	**1.3**	**2**
	CD(p=0.05)	**2.7**	**2.8**	**4.1**

Table 2: Influence of foliar application of Nano nutrients (N, Zn and Cu) on Number of branches and Days to 50% Flowering (days) in Capsicum.

T.No	**Treatments**	**No.of branches plant^{-1}**	**Days to 50% Flowering (days)**
T_1	100% RDF(N:P:K)(250:150:150kg/ha)	11.6	47.5
T_2	25% RDF -N : 100% RDF (P:K) + 75% Nano N	14.6	39.7
T_3	50% RDF -N : 100% RDF (P:K) + 50% Nano N	14.3	41.5
T_4	75% RDF -N : 100% RDF (P:K) + 25% Nano N	13.7	42.3
T_5	100% RDF (P:K) + 100% Nano N	14.7	39.0
T_6	100% RDF (N:P:K) + Nano Zn	12.7	47.0
T_7	100% RDF (N:P:K) + Nano Cu	13.3	46.7
T_8	100% RDF (N:P:K) + Nano Zn + Nano Cu	14.1	45.7
T_9	100% RDF (P:K) + 100% Nano N + Nano Zn	14.8	38.4
T_{10}	100% RDF (P:K) + 100% Nano N + Nano Cu	14.7	38.6
T_{11}	100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu	15.1	37.6
T_{12}	25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu	14.9	39.7
T_{13}	50% RDF -N : RDF (100% P:K) + 50% Nano N + Nano Zn + Nano Cu	15.0	41.1
	S.E.D	**0.2**	**0.9**
	C.D(p=0.05)	**0.5**	**1.9**

Days to 50 percent flowering

The data presented in Table 3 shows a significant difference in days to 50 percent flowering. The early flowering was recorded in T_{11} -100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu (37.6 days) followed by T_9 -100% RDF (P:K) + 100% Nano N + Nano Zn (38.4 days) and T_{10} - 100% RDF (P:K) + 100% Nano N + Nano Cu (38.6 days) followed by T_5 - 100% RDF (P:K) + 100% Nano N (39 days) , T_2 -25% RDF -N : 100% RDF (P:K) + 75% Nano N(39.7 days) and T_{12}- 25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu (39.7 days)which recorded on par values .Delayed 50% flowering was recorded in T_1-100% RDF(N:P:K)(250:150:150kg/ha) (47.5 days).

PEAK FLOWERING STAGE

IFFCO NANO NUTRIENTS

FOLIAR APPLICTION OF NANO NUTRIENTS

Discussion

Vegetables plays an important role in Indian economy and there is also a growing demand for high value fresh vegetables to feed the corresponding burgeoning population with dwelling nutrition. The main factors which influence production and productivity are nutrient and environmental condition. The conventional fertilizers are bulk composite and are not available for root and have low efficiency and also when excess release of fertilizer may produce toxicity and destroy the ecological balance of soil and the rest is converted into insoluble form of salts. Also due to large particle size and less solubility it has high loss by leaching or run off.

Nanotechnology is a new branch of science, which deals at the nanoscale(atoms). A particle with higher surface area has a greater number of reaction sites than a particle with low surface area

thus, results in enhanced chemical reactivity. Nanotechnology use in nanoscale fertilizer particles has offered new techniques in improving existing crop management (Ghafari and Razmjoo, 2013). The Nano nutrients taken for the study are Nano Nitrogen, Nano Zinc and Nano copper. These nutrients enhance the growth and yield parameters when applied as foliar application. The application of foliar shower is a main crop management strategy, which may help in maximizing the crop yield and quality (Haytova, 2013)

The present study on "Influence of foliar application of Nano nutrients (Nano N, Nano Zn and Nano Cu) on growth of Capsicum "was studied to find the best treatment for utmost production of Capsicum. The findings described in the preceding chapter have been critically discussed here in detail.

Growth Parameters

Growth is a major indicator of fertilizer uptake and adsorption. Among various treatments tested, plants which are treated with 100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu(T_{11}) (57.4 cm) followed by 25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu(T_{12})(56.2 cm) recorded highest and utmost plant height at 45^{th} ,75^{th} DAT and final harvest which registered on par values and increase in height by 20.59 % than T_1 -100% RDF (N:P:K)(250:150:150kg/ha)(47.6 cm)followed by 25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu(T_{13}) (55.4cm) followed by 100% RDF (P:K) + 100% Nano N + Nano Zn(T_9) (55.3cm) which were also on par and also registered an increase in height by 16.39% than T_1-100% RDF(N:P:K)(250:150:150kg/ha)(47.6 cm). The results of the experiment were also in agreement with findings of (Abdel et al., 2019) on red radish.

As indicated by Bahmaniar and Sooaee Mashaee (2010) nitrogen positively affects the plant height. The rise might be due to cell growth under nitrogen. Several studies indicated that foliar application of some nanoparticles can significantly improve plant growth (Mandeh et al., 2012; Song et al., 2013). Moreover, plant height was more magnified when Nano fertilizer was mixed with the conventional ones, even at a lower application rate (Benzon et al., 2015). Also, the combination of other Nano Nitrogen with Nano Zinc might also be a reason for increase in plant height. The findings are like (Ramesh railaya et al., 2015) in tomato.

The physiological mechanisms through which Nano nitrogen in combination with conventional fertilizers and Nano zinc and Nano copper exerts their effects may depend on enzymes for hormone synthesis. Zinc plays an important role in many biochemical functions within plants. Zinc is an essential component of over 300 enzymes (Fox and Guerimot, 1998). Also, zinc is involved in synthesis of tryptophan which is a precursor of IAA (indole acetic acid) (Spiegel-Roy and Goldschmidt ,2008). Nitrogen in Nano form results in better absorption and less nutrient loss and more nutrient use efficiency due to small size to large surface area volume also Nitrogen plays chief role in protein and chlorophyll synthesis which result in dark green leaves and promotes leaves stem and vegetative parts of plant (Bloom, A.J.,2015). Nano fertilizers are aimed to make nutrients more available to leaves, consequently increasing nutrient use efficiency (Suppan, 2013). Some characteristics of nanoparticles, including the large specific surface area, unique magnetic/optical properties, electronic states, and catalytic reactivity confer nanoparticles a better reactivity than the equivalent bulk materials (Agrawal and Rathore, 2014)

Number of branches plant^{-1} was also influenced by the Nano nutrients. T_{11} - 100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu (15.1) followed by T_{13} - 50% RDF -N : RDF (100% P:K) + 50% Nano N + Nano Zn + Nano Cu (15.0) followed by T_{12} - 75% RDF -N : RDF (100% P:K) + 25% Nano N + Nano Zn + Nano Cu (14.9) which is on par showed the utmost number of

branches and an increase in number of branches by 30.17 % than T_1- 100% RDF(N:P:K)(250:150:150kg/ha)(11.6) followed by T_9 -100% RDF (P:K) + 100% Nano N + Nano Zn (14.8), T_{10} -100% RDF (P:K) + 100% Nano N + Nano Cu (14.7), T_5-100% RDF (P:K) + 100% Nano N (14.7) and T_2 - 25% RDF -N : 100% RDF (P:K) + 75% Nano N (14.6) which is also on par and increase in number of branches by 27.59 % than T_1 -100% RDF (N:P:K) (250:150:150kg/ha)(11.6).

The results are in close agreement with the finding of Khospeyak et al., (2016) who reported that the plant height, number of lateral branches, number of umbels per plants, number of grains per plant, 1000-grain weight were significantly higher with Nano fertilizer treatment over conventional fertilizers.

As the growth is influenced by Nano nitrogen and zinc there is increase in number of branches per plant. The increase in number of branches per plant with increase in N rate may be since nitrogen promoted vegetative growth and branching on the inflorescence. These results agree with those documented by Uddin *et al*. (1992).

Number of days to 50% flowering is an important criterion that governs the earliness of a crop. It is influenced by diverse factors like genetic, environmental, physiological, nutritional, hormonal, and cultural. The present study revealed that plant nutrient at timely condition is a pre-requisite for onset of early flowering (Balakrishnan, 1986).

Among the ten treatments, T_{11} -100% RDF (P:K) + 100% Nano N + Nano Zn + Nano Cu (37.6 days) followed by T_9 -100% RDF (P:K) + 100% Nano N + Nano Zn (38.4 days) and T_{10} - 100% RDF (P:K) + 100% Nano N + Nano Cu (38.6 days)which is on par and increased by 20.85 % than T_1-100% RDF(N:P:K)(250:150:150kg/ha) followed by T_5 - 100% RDF (P:K) + 100% Nano N (39 days) , T_2 -25% RDF -N : 100% RDF (P:K) + 75% Nano N (39.7 days) and T_{12}-25% RDF -N : RDF (100% P:K) + 75% Nano N + Nano Zn + Nano Cu (39.7 days)which is also on par has 17.89 % increase than T_1-100% RDF(N:P:K)(250:150:150kg/ha).Delayed 50% flowering was recorded in T_1-100% RDF(N:P:K)(250:150:150kg/ha) (47.5 days). The results are similar with (Laware and Shilpa Raskar, 2014).

Flowering is controlled by four main pathways promoting flowering phase: photoperiodic, vernalization, autonomous, and hormonal (Zeevaart ,2006). Autonomous and hormonal pathways are thought to be independent from environmental factors, but connected with plant development and age (Mouradov *et al*. 2002; Wang *et al*. 2012). Nano Zinc enhances cation-exchange capacity of the roots, which in turn enhances absorption of essential nutrients, especially nitrogen which is responsible for higher protein content. Nitrogen is the main component of protein, and all types of enzymes are mainly composed of proteins. Nucleic acid, nucleotides, coenzymes, phospholipids, and cytokinins contain nitrogen. Previous studies have also confirmed that many hormones such as gibberellin and cytokinin are closely related to the regulation of flowering (Bernier and Perilleux ,2005).

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UTILIZATION OF PADDY EXPERT SYSTEM APP AND ITS EFFECTIVENESS ON FARMERS IN TIRUNELVELI DISTRICT OF TAMIL NADU

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Abstract

Expert System is a computer program that stimulates the judgment and behaviour of a human (or) an organization that has expert knowledge and experience in a particular field. The study was undertaken to find out the extent of utilization of android app on paddy expert system and its effectiveness as perceived by the paddy farmers. The present study was carried out during December 2019 among paddy growers in the vasudevanallur Block of Tirunelveli district. In this study, perception regarding the utilization of android app on paddy expert system was studied. Half (55%) of the paddy farmers possessed medium level of extent of utilization followed by (23.4%) of the farmers possessed low level of extent of utilization and remaining (21.6%) of the farmers possessed high level of extent of utilization respectively. This study results will allow the expert system developers to tailor the content and procedures to match end-users' expectations. The extension workers will have to demonstrate, and train users in handling and using different android apps which will help to improve their skills and make effective use of them.

Introduction

ICT plays a vital role as decision support system to the farmers. Through ICT, farmers can be accessed with the recent information about agriculture, weather, new varieties of crops, protection measures to increase the agricultural production. ICT can be used to provide farmers with reliable information and services, thereby promoting a more remunerative agriculture development (Raghuprasad et al., 2012). The dissemination of adequate, efficient, and tailored technologies related to agro-climatic zone, size of farm and soil type etc. to the farmers is deficient in Indian agriculture and it is the real challenge in front of policy makers in India. An Expert System is a computer program that stimulates the judgment and behaviour of a human (or) an organization that has expert knowledge and experience in a particular field. It is program that emulates the interaction a user might have with a human expert to solve a problem. An Expert System is a problem solving and decision-making system based on knowledge of its task and logical rules or procedure for using knowledge. Both the knowledge and the logic are obtained from the experiences of a specialist in the area. Tamil Nadu Agricultural University (TNAU) has introduced a bilingual version of six mobile apps on expert system in coconut, paddy, banana, rice, sugarcane and livestock which were made available in Google play store and in m-apps.gov.in for the benefit of farmers, extension officials, researchers and students Karthikeyan (2018). These apps on expert system were released in the public domain during 2018. However, the utility of these expert system mobile apps by the farmers is not known to the scientists of TNAU. The information regarding the utility perception by the actual beneficiaries namely farmers is needed to improve its utility and performance in future.

Methodology

This study was carried out during December 2019 to January 2020 among paddy growers of Tirunelveli district in Tamil Nadu. Tirunelveli district was purposively selected and it had 19 blocks. Of these, vasudevanallur block had maximum area under paddy crop and hence it was selected for the study. In the selected block, the top six villages that had maximum area under paddy crop were selected for the study. Ten paddy farmers who possessed android mobile phones and used the expert system app on paddy for accessing agricultural information were identified through snowball sampling from each of the selected villages. Accordingly, 60 paddy growers were selected as respondents for this study. Ex-post facto research design was followed for this study. The data was collected from the respondents with the help of a well structured interview schedule. The collected data was statistically analyzed using SPSS Software. The statistical tools such as percentage analysis, cumulative frequency, correlation analysis, multiple regression analysis was used.

Result & Discussion

Farmer perception about the utilization of paddy Expert System

The paddy expert system contains various contents. An attempt was made to analyze the extent of utilization of paddy expert system of paddy farmers with respect to content referred such as botany, season and variety, climate, planting material, cultivation practices, irrigation management, nutrient management, crop protection, farm implements, post harvest technology, marketing, institution, precision farming, FAQ. Percentage analysis was performed and the findings are given in the Table 1.

Distribution of respondents according to their Perception about the stage wise utilization of the app on paddy expert system (n=60)

S.No	Cultivation stages	Very frequently (>3 times)		Frequently (Twice)		Less frequently (At least once)		Not at all	
		F	%	F	%	F	%	F	%
1	Sowing	5	8.33	20	33.4	30	50.0	5	8.3
2	Transplanting	10	16.6	17	28.4	25	41.7	8	13.3
3	Nutrient management	7	11.6	27	45.0	11	18.4	15	25.0
4	IPM	18	30.0	27	45.0	8	13.3	7	11.6
5	Weed management	5	8.3	25	41.7	20	33.4	10	16.6
6	Harvesting	4	6.6	10	16.6	20	33.4	26	43.3
7	Threshing	6	10.0	16	26.7	33	55.0	5	8.3
8	Marketing	25	41.7	26	43.3	5	8.3	4	6.6

About half (50.00%) of the respondents had less frequently utilized the paddy expert system app during the sowing period. Farmers were unaware about the seed borne disease occurrences

during the sowing stage. So, they had less frequently used this app during sowing stage. Two-fifth (41.66 %) of the respondents had less frequently referred paddy expert system app during the transplanting period, as they were unaware about the disease occurrence during the transplanting stage. Hence, they had less frequently used this app transplanting stage. Nearly half (45.00%) of the respondents had used this app frequently for nutrient management. About one-tenth (11.66%) of the respondents had not at all referred this app for nutrient management. This may be because of bio fertilizer usage was not known to nearly one-tenth of the respondents. Nearly half (45.00 %) of the respondents had frequently used this app for Integrated Pest Management. This is due to the presence of detailed information regarding pest and disease management in the expert system besides the farmers felt need to manage the pests in their paddy crop.

Two-fifth (41.66%) of the respondents had frequently referred this app for weed management in Paddy crop. This is because of the necessity for the farmers regarding weed management methods in the expert system. About 43.33 per cent of the respondents had not at all referred this app during harvesting period as they followed their indigenous knowledge for harvesting practices. Again 43.3 per cent of the respondents had frequently referred the app for marketing to gather various markets price information for paddy. This findings are in line with the results obtained by Kabir (2015) who conducted a study on attitude and level of knowledge of farmers on ICT based farming in Bangladesh and reported that major proportion (66.77%) of the farmers were perceived the information of post harvest technology at less appropriate manner. A sizeable portion (27.88%) of farmers perceived market information as most appropriate information for their farming through the daily updates on the prices of agricultural commodities in the local markets.

Farmers perception about content referred from paddy expert system

The paddy expert system contains various contents. An attempt was made to analyze the extent of utilization of paddy expert system of paddy farmers with respect to content referred such as botany, season and variety, climate, rice ecosystem, nursery management, cultivation practices, nutrient management, crop protection, farm implements, post harvest technology, implement, institute, FAQ. Percentage analysis was performed and the findings are given in the Table 2

Distribution of respondents according to their Perception about the content referred from paddy expert system (n=60)

S. No.	Paddy expert system app	Extent of Utilization							
		Very frequently (>3 times)		Frequently (Twice)		Less frequently (At least once)		Not at all	
		F	%	F	%	F	%	F	%
1	Botany	3	5	4	6.6	20	33.3	33	55
2	Season and variety	15	25	20	33.3	15	25	10	16.6
3	Climate	5	8.3	9	15	13	21.6	33	55
4	Rice ecosystem	5	8.3	24	40	20	33.3	11	18.3

5	Nursery management	10	16.6	17	28.3	25	41.6	8	13.3
6	Cultivation practices	12	20	22	36.6	18	30	8	13.3
7	Nutrient management	7	11.6	27	45	11	18.3	15	25
8	Crop protection	15	25	27	45	8	13.3	7	11.6
9	Farm implements	4	6.6	5	8.3	15	25	36	60
10	Post harvest technology	5	8.33	14	23.3	25	41.6	16	26.6
11	Marketing	25	41.7	26	43.3	5	8.3	4	6.6
12	Institutes	3	5	7	11.6	13	21.6	30	50
13	FAQ	4	6.6	4	6.6	10	16.6	42	70

Table 2 reveals that more than half (55.00%) of the paddy growers had not at all referred botany content because they had already known the description about rice crop parts. About 33.33 per cent of the paddy growers had frequently referred season and variety content. This is because the images of different varieties of paddy are clearly provided in the expert system. Table 2 also reveals that more than half (55.00%) of the paddy growers had not at all referred the climate content because they followed their indigenous knowledge about the varietal selection based on the climatic condition. Two-fifth (40.00%) of the paddy growers had frequently referred the rice ecosystem content. Because it contains the package of information about the cultivation system such as water management, manures, stand establishment. About 41.66 per cent of the paddy growers had less frequently referred the nursery management contents. They were not unaware about the disease occurrence during nursery stage. So, they had less frequently referred this content during nursery stage. About more than half (56.66%) of the paddy growers had frequently referred the cultivation practices. The detailed information of each practice is given in this content. So, they had frequently referred this content during cultivation stage. More than two-fifth (45.00%) had frequently referred nutrient management content. 25 per cent of the paddy growers had not referred this content, this is because of bio fertilizer usage was not known to nearly one-tenth of the respondents. More than two-fifth (45.00%) of the paddy growers had frequently referred crop protection contents.

This is due to the presence of detailed information regarding pest and disease management in the expert system besides the farmers felt need to manage the pest in their paddy crop. Majority (60.00%) of the paddy farmers had not at all referred the farm implement content. This is because basic information of the farm implements is only given in this content. But the farmers expected to need the information about the availability and subsidies of farm implements in this content. More than two-fifth (41.66%) of the paddy growers had less frequently used the post harvest technology contents. They followed their indigenous knowledge about post harvest practices. About 43.33 per cent of the paddy growers had frequently referred the marketing content to gather various market price. The detail about domestic market, export, export standard was briefly given in this content. About half (50.00%) of the paddy growers had not at all referred the institute contents. This content

contains the information about the varieties released by the institutes. But the content was not updated. Lack of new released varieties in this content. So, they had not referred the institutes. Majority (70.00%) of the paddy growers had not at all referred the FAQ content, because the questions are limited. So, farmers can"t fulfill their clarification about doubts in cultivation.

Conclusion

Expert System is a computer program that stimulates the judgment and behaviour of a human (or) an organization that has expert knowledge and experience in a particular field. The expert system consists of three components such as decision support system, crop doctor, information system. The study assessed the extent of utilization of android app on paddy expert system by using the farmers for acquiring information on different areas related to paddy cultivation. In this study the farmer's perception regarding the utilization of android app on paddy expert system was analysed. Half (55%) of the paddy farmers possessed medium dimension of extent of utilization followed by (23.4%) of the farmers possessed low dimension of extent of utilization and remaining (21.6%) of the farmers possessed high dimension of extent of utilization respectively. paddy growers' perception had shed light on various difficulties encountered by them in using the expert system. The study results will allow the expert system designers to adjust the content ad procedures to match end user's expectation. The extension worker will have to demonstrate farmers in handling and using exclusive mobile apps on expert device in order to help improve their skills and make effective use of them.

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STUDIES ON THE EFFECT OF INCUBATION PERIOD AND THE AGE OF INOCULUM ON THE AMYLASE ENZYME PRODUCTION BY *Bacillus* SPP. UNDER SOLID STATE FERMENTATION

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Abstract

One of the most common enzymes used in industry is amylase. These enzymes are crucial in the hydrolysis of starch molecules into polymers made up of glucose units. Amylases could be used in a variety of industrial operations, including the food, fermentation, and pharmaceutical industries. Even though amylases can come from a variety of sources, including plants, animals, and microorganisms, industrial demands are often satisfied by microbial enzymes. From the cassava waste, the bacterium was separated. Bacillus amyloliquefaciens, Bacillus licheniformis, and Bacillus subtilis were identified as the bacteria that were isolated using staining techniques, motility tests, plating on certain conditions, and biochemical assays. After incubation, the starch agar media surrounding the microbial colonies lost its blue colour, which was an indication that these Bacillus spp. were producing amylase. Waste from cassava was used as the substrate for the synthesis of amylase. Using these Bacillus spp., solid state fermentation was used to assemble amylase. The effect of different incubation times and inoculum ages on the synthesis of enzymes by Bacillus spp. was clearly demonstrated in the current investigation. Amylase activity is measured using techniques like the Plate assay and a reduction in starch-iodine colour intensity.

Key words: *Amylase, Age of inoculum, Bacillus spp, Cassava waste, Incubation period.*

Introduction

According to Azzopardi *et al*., (2016), there are three primary forms of amylases: beta-amylase, found in plants and microorganisms, and gamma-amylase, found in both animals and plants. Alpha-amylase is found in animals, people, microbes, and plants. A global secretory enzyme among them might be α-Amylase (1,4-a-D-glucan glucanohydrolase, EC 3.2.1.1). The amylase enzymes have hydrolyzed the starch molecules to form a variety of compounds, such as dextrins and gradually smaller polymers made of glucose units. The starch, detergent, beverage, and textile sectors all depend heavily on amylases, and their commercial production from microbes accounts for 25 to 33 percent of the global enzyme industry.

Currently, the global enzyme market is valued at about US$ 2.7 billion and is growing at a rate of 4% per year (Abd-Elhalem *et al*., 2015). Nowadays, *Bacillus* bacterial species manufacture most of the amylase enzymes. Media engineering, the addition of different nutrients, and the optimization of proper growth conditions can all be used to produce large amounts of enzymes. Because these methods promote the growth of microbes and the production of better enzyme, it is crucial for bacterial cultures to have optimal growth conditions (Elmansy *et al*., 2018). In this work, various inoculum ages and incubation times were examined and optimised for greater and larger amylase enzyme synthesis.

In recent years, solid state fermentation (SSF) has attracted a lot of attention and is viewed as an affordable alternative for the synthesis and use of enzymes (Govarthanan *et al*., 2015). The organic wastes utilization as a substrate in solid state fermentation process reduce the production costs and capital investment involved in the amylase enzyme production. Besides that, it increases the awareness of the extreme increase of waste materials and the important of waste management

by the utilization of organic wastes as substrates. *Manihot esculenta*, also known as cassava, originated in Brazil and Paraguay, but before the advent of the Colombus, had spread throughout the tropical parts of South and Central America. It is currently one of the most important food crops in tropical regions and ranks as the world's sixth most important food crop. Cassava, often known as "bread of the tropics", "meal of the poor", or "poverty fighter" is a key carbohydrate source in tropical Africa due to its drought resistance and ability to thrive in practically any type of soil, even marginal soils. However, it is not a well-known or widely used food crop in Western countries.

Cassava is a tropical, perennial herbaceous plant that can reach a height of 3 to 5 metres. The leaves are palmate and highly indented, with 3–7 lobes linked to a thin stem with long petioles. Small greenish-yellow blooms create panicles, which mature into seed capsules that rupture to disperse seeds following maturation or ripening. The plant's roots produce enormous starchy tubers with a white flesh and a dark brown fibrous covering, comparable to sweet potatoes. Cassava is one of the most adaptive plants in terms of habitat. It can thrive in both humid tropical and drought situations, and it can adapt to grow in poor soil where other plants cannot. This plant requires little maintenance and can defend itself against a wide range of predators by its deadly latex, which runs freely through the plant leaves. It is most suited to growing in tropical climates.

Waste management had become a big issue in both developed and developing countries around the world. While developed countries are only partially capable of managing the trash problem, it has become a complicating factor for underdeveloped countries due to ineffective and fraudulent waste management strategies. In Nigeria, for example, the habit of dumping unsorted solid waste into the environment has become the standard. As a result, it is not uncommon to come across heaps of solid garbage placed in undeveloped property, unfinished buildings, and open fields Agricultural refuse, particularly waste from cassava production, accounts for a larger percentage of total wastes produced annually, posing a disposal problem in the Salem District of Tamil Nadu.

Bioconversion of cassava waste into protein, biomolecules, organic acids, and food components, among other things, has been examined as an industrial development for the use of cassava waste. As a result, the primary goals of the study were to isolate and characterise amylolytic bacteria from cassava waste dumpsites as well as to perform a partial characterization of the enzyme production and its features in relation to the effects of various incubation periods and inoculum ages. The study was conducted at a pH of 6.0 and a temperature of 50°C. Maltose and beef extract were discovered to be the optimum carbon and nitrogen sources for the greatest enzyme synthesis in the earlier research.

Materials and Methods

Isolation of *Bacillus* spp.

From the solid waste of cassava, amylolytic bacteria will be identified (Cassava baggase). The serial dilution method will be used to isolate the bacteria on nutrient agar plates. In this instance, 0.1 ml of the sample's dilution (10^5) will be inoculated on NA medium for the appropriate bacteria. 24 hours will pass while the infected media is incubated at 37°C. Colony forming units per millilitre (cfu ml^{-1}) will be used to measure the number of discrete colonies that emerged on the plates. To produce the pure culture, the isolates will be subcultured once more on slants. The slants will be kept at 4 °C.

Screening and identification of amylase producer

By inoculating isolated bacterial colonies on a starch agar plate, they will be further evaluated for their amylolytic capacity while being kept at 4°C. Plates with inoculations will be incubated at 37°C for three days. Amylolytic bacteria will be detected after three days of incubation

by saturating the plates with Gram's iodine solution (1 g of iodine crystals and 2.0 g of potassium iodide will be dissolved in 100 ml of distilled water, stored at room temperature) (Pokhrel *et al*., 2013).

Characterization of bacterial isolates

A dark blue starch-iodine complex was produced by the reaction of starch and iodine, and it completely covered the agar. The positive colonies show an area of clear zone of hydrolysis around the colonies when flooded with gram's iodine solution, but the negative colonies do not, as seen by a blue-black colouring on starch agar. (Benkiar *et al*., 2013; Kaur *et al*., 2012; Parmar *et al*., 2012).

Optimization of culture conditions

The influence of culture conditions in order to produce a large amount of amylase enzyme, the current study will be conducted at various incubation periods (1, 2, 3, 4, 5 and 6) and diverse inoculum ages (1, 2 and 3 days).

Solid state fermentation

A bacterial amylase production containing (g/l) KH_2PO_4 - 1.4; NH_4NO_3 - 10; KCl - 0.5; $MgSO_4.7H_2O$ - 0.1; $FeSO_4.7H_2O$ - 0.01; starch - 20 gm; and distilled water will be added to this to adjust the required moisture level will be added to five grams of substrate (Cassava Solid Waste). The flasks' contents will be well mixed before being autoclaved at 121°C for 20 minutes. Solid state fermentation will be carried using 2 ml of each suspension of *Bacillus amyloliquefaciens, Bacillus licheniformis,* and *Bacillus subtilis* for a total of 72 hours at 30°C with a substrate starting moisture content of 64%. (Castro *et al*., 2010).

Enzyme extraction

Cultures were mixed with 22 ml of 0.1 M phosphate buffer (pH-6.5) and shaken on a rotary shaker for 30 minutes at 19°C and 140 rpm. This mixture was filtered using a cheesecloth, and centrifugation was carried out for 15 minutes at 8000 rpm and 4°C. The filtrate from the centrifugation's supernatant was used for additional research after being filtered with Whattman Number-1 filter paper.

Estimation of amylase activity

The rate at which maltose is released from starch, which is measured by its capacity to decrease 3,5 dinitrosalicylic acid, was used to determine the amylase activity (DNSA). The amount of enzyme that will release 1 mg of maltose per minute at 25°C was defined as one unit of amylase activity. In phosphate buffer, the substrate 1 percent cassava baggase was gelatinized. 1 ml of the enzyme solution and 1 ml of the substrate made up the reaction mixture. It was incubated for 5 minutes at 25°C before being stopped by adding 1 ml of the DNSA colour reagent. The combination was warmed in a water bath for five minutes at 100°C, cooled, and then diluted with ten millilitres of distilled water. The reaction mixture was allowed to stand for 15 min at room temperature and the optical density read at 540nm. A unit of amylase activity was expressed as:

$$\text{Enzyme activity (Units/ml)} = \frac{\mu\text{g of maltose released}}{\text{Volume of enzyme taken(1 ml)} \times \text{Time of incubation}}$$

Assay of enzyme activity

Decrease in starch-iodine color intensity

In the presence of iodine, starch reacts to create a deep blue complex. The starch hydrolyzed gradually after that, changing from white to red dish brown. Several methods for the quantitative determination of amylase are presented by various groups to support this characteristic. By

measuring the decline in the iodine colour response, this technique quantifies the dextrinizing activity of amylase.

Plate assay

Agar plates that had been modified with starch were used for the plate assay. The agar plates were formed by blending 1.5 percent agar and 2 percent starch. After agar had solidified, a well with a diameter of about 10 mm was aseptically cut out with a cork borer. The culture filtrate was placed inside the well, which was then overnight-incubated at 37°C. The agar was covered with a layer of 1 percent iodine solution, and the hydrolytic zone around the well was seen as well. Sterilized water was added to the separate well to preserve the negative control.

Result and Discussion

Singh *et al*., (2015) confirmed the production of amylase enzyme from *Bacillus* isolates using iodine on starch agar medium, and the developing of clear zone around bacterial growth indicates for amylase activity. Amylase enzyme were produced by *Bacillus amyloliquefaciens, Bacillus licheniformis,* and *Bacillus subtilis* using cassava waste from Sago processing industry, Salem. The bacterial isolate used in this investigation that produced amylase more efficiently provided a preliminary description like this: gram-positive, one micron long, spore-forming bacilli, with core spores often smaller than the cell. Gram staining, a motility test, a selective medium, and biochemical assays were used to isolate and describe the *Bacillus* spp. (*Bacillus amyloliquefaciens, Bacillus licheniformis,* and *Bacillus subtilis*). We have already discussed the ideal pH and temperature for *Bacillus amyloliquefaciens, Bacillus subtilis,* and *Bacillus licheniformis* to produce alpha amylase. In this study, we identify the ideal incubation time and inoculum age in order to further define enzyme production.

Table 1 lists the effects of various incubation times (1, 2, 3, 4, 5 and 6 days) on the production of the amylase enzyme by the bacteria *Bacillus amyloliquefaciens, Bacillus licheniformis,* and *Bacillus subtilis*. Table 1 demonstrates that, aside from 3 days on control medium, none of the studied incubation periods increased the enzyme production by these *Bacillus* spp. After 3 days of incubation, the enzyme activity was shown to be declining, even though amylolytic activity was adversely affected. A lengthy incubation period may result in the denaturation, breakdown, or inhibition of an enzyme. Similar findings with the amylase enzyme isolated from *B. licheniformis* ATCC 12759 and *Bacillus* isolates suggested that extended incubation time lasting longer than 2 days affected enzyme activity. (Nurullah, 2011; Kanimozhi *et al*., 2014).

Table 1: Effect of incubation periods on the amylase production

S.No.	**Incubation period in days**	**Enzyme activity (U/ml)**		
		B. amyloliquefaciens	***B. licheniformis***	***B. subtilis***
1	1	533	540	470
2	2	740	775	686
3	3	798	854	744
4	4	677	683	650
5	5	350	365	314
6	6	225	228	205

In this present study, the enzyme production was found maximum at incubation period of 3 days (854 Uml^{-1}) recorded by *B. licheniformis* and found minimum at incubation period of 6 days (205 Uml^{-1}) recorded by *B. subtilis* (**Table 1**).

After adjusting the incubation time, the optimal inoculum ages for cell growth and amylase production were 1, 2, and 3 days. Demirkan *et al*., (2017) showed that an inoculum age of two days improved *Bacillus* sp. growth and Amylase output. The best enzyme activity (52.06 U/mg/min) and protein content (519 g/ml) were found with a 24 h old inoculum, according to Zar *et al*., (2012). This may be because the bacteria were in their active mode of development and by further extending the age of the inoculum (32 h old). The productivity of the enzymes markedly decreased. At a 40-hour inoculum, a further reduction in enzyme activity (33.14 U/mg/min) was observed. It was due to the accumulation of other byproducts such as secondary and tertiary metabolities or proteolyses. Effects of different ages of inoculum on amylase production by *Bacillus amyloliquefaciens, Bacillus licheniformis, Bacillus subtilis* are summarized in Table-2.

Table 2: Effect of age of inoculum on the amylase production

S.No.	Age of Inoculum (days)	Enzyme activity (U ml^{-1})		
		B. amyloliquefaciens	***B. licheniformis***	***B. subtilis***
1	1	750	779	690
2	2	890	915	815
3	3	615	635	564

In this present study, the enzyme production was found maximum at a age of inoculum of 2 days (915 Uml^{-1}) recorded by *B. licheniformis* and found minimum at incubation period of 3 days (564 Uml^{-1}) recorded by *B. subtilis* (**Table 2**).

Conclusion

In the latest research, the production of amylase was determined by the natural bacterial flora of the cassava baggase, which was taken from Salem's agricultural industry. Three bacterial isolates were identified as positive based on the presence of a zone of hydrolysis in starch agar plates and the highest levels of enzyme activity out of a total of 15 bacterial isolates that were tested to produce extracellular amylase in starch agar medium. *Bacillus amyloliquefaciens, Bacillus licheniformis,* and *Bacillus subtilis* were employed to produce amylase, and cassava waste was used as a substrate under solid state fermentation for all three of the bacterial isolates that were identified after initial screening.The identified bacterial isolate that shown a significant amount of amylase activity can be further optimised for various incubation times and ages of inoculum for bacterial species growth and for maximum enzyme synthesis.

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EFFECT OF INOCULATION OF SALT TOLERANT RHIZOBIA ON NODULE LEGHAEMOGLOBIN AND N CONTENT OF GROUNDNUT var. VRI-3 in normal and saline soil

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Abstract

Increasing soil salinity represents a major constraint for agriculture in arid and semi-arid lands, where mineral nitrogen (N) deficiency is also a frequent characteristic of soils. Biological N fixation by legumes may constitute a sustainable alternative to chemical fertilisation in salinity-affected areas, provided that adapted cultivars and inoculants are available. Here, the performance ofGroundnut var. VRI-3 with rhizobial strainsin their salt tolerance was evaluated under normal and saline soil under pot culture condition. The salt tolerant Rhizobium sp inoculated plants recorded more leghemoglobin content and N content in all sampling periods, 30, 60 and 90 DAS. The salt tolerant Rhizobium sp GNR CD-4 inoculated groundnut plants gave maximum nodule leghemoglobin of 1.245 mg g-1 of nodule and nitrogen content of 254.00 mg plant-1 in normal soils and nodule leghemoglobin content of 1.187 mg g-1 of nodule and nitrogen content of 215.15 mg plant-1 in saline soil at 90 DAS. The GNR CD-8 inoculated plants recorded leghemoglobin content of 1.140 mg g-1 of nodule and nitrogen content of 246.25 mg plant-1 in normal soil and 1.050 mg g-1 nodule and 198.00 mg plant-1 in saline soil. Under non-saline conditions, higher Nodule Leghaemoglobin and N content of Groundnut var. VRI-3 in normal soil rather thanand saline soil.

Key words: *Rhizobia, Nodule Leghaemoglobin, N content, Groundnut*

Introduction

Biological nitrogen fixation is an efficient source of nitrogen in the biosphere. Leguminous plants through their symbiotic relationship with certain gram-negative soil bacteria, collectively known as rhizobia, help to fix atmospheric nitrogen. Herridge et al. (2008) estimated that about 21 Tg of nitrogen is fixed annually through the crop legume-rhizobia symbiosis. The bacteria form nodules on the roots or rarely on the stem of legume hosts and by fixing atmospheric nitrogen into ammonia, they provide an easy and inexpensive way to enhance soil fertility and agricultural productivity. However, a number of factors affect the rhizobium-legume symbiotic relationship. These include the host symbiont compatibility and the physicochemical conditions of the soil, especially salinity and soil pH, nutrient deficiency, mineral and heavy metal toxicity, temperature extremes, insufficient or excessive soil moisture, etc. Salinity in particular adversely affects the survival and proliferation of Rhizobium spp. in soil and rhizosphere, in addition to reducing plant growth, photosynthesis and demand for nitrogen from host plant. However, rhizobial populations are known to vary in their tolerance to major environmental factors (Wei *et al*., 2008). Singleton *et al*. (1982) showed that rhizobium strains can grow and survive at salt concentrations which are inhibitory to most agricultural legumes. Inoculation of such strains would enhance the nodulation and nitrogen fixing ability of the leguminous plants growing under saline conditions (Zahran, 1999; Ali et al., 2009). Furthermore, the ability of legume hosts to grow and survive in saline soils was also shown to improve when they were inoculated with salt-tolerant strains of rhizobia (Zou *et al*., 1995; Shamseldin and Werner, 2005). In this paper, we present the results from astudy to Effect of

inoculation of salt tolerant Rhizobia on Nodule Leghaemoglobin and N content of Groundnut var. VRI-3 in normal and saline soil under pot culture condition.

Materials and Methods

The soil used for conducting the pot culture experiments was obtained from garden land of the experimental farm in department of Microbiology, Faculty of Agriculture, Annamalai University, Chidambaram, and saline soil was obtained from saline areas of Cuddalore district of Tamil Nadu.

Potting

The cement pots (30 cm diameter) were used for conducting pot culture experiments. They were surface disinfected with copper sulphate solution (5%) and filled with unsterile and sterile soil as per the requirement of the experiment. The soil was disinfected by using 10% formaldehyde solution for 1-3 days.

Manures and fertilizers

Well decomposed farm yard manure, nitrogen through urea, phosphate through single super phosphate and potassium through muriate of potash were used as per the levels included in the study. Materials and Methods.

Culture used

Reference strain

The reference strain GNR-AU 1 was obtained from Department of Agricultural Microbiology, Faculty of Agriculture, and Annamalai University, India was used in the present study.

Cultivars used

Groundnut (*Arachis hypogaea* L.) Variety VRI-3 was used for the present study.

Inoculum production and application

Rhizobium inoculum production and seed bacterization

The Rhizobium tropici GNR CD-4 logarithmic phase culture inoculum was produced by using yeast extract mannitol broth. The *Rhizobium tropici* GNR CD-4 inoculum containing 1010 cells/ml was used at the rate of 300 ml/kg of seeds of groundnut. The surface sterilized seeds mixed with the culture broth were shade dried. The dried seeds were taken for sowing.

Total 10 root nodules samples along with rhizosphere soil samples with intact root nodules of groundnut plants were collected from saline tract of cuddalore districtof Tamilnadu. Total of 7 salt tolerant *Rhizobium* isolates were obtained from the root nodules of soybean grown in saline soils of cuddalore districtof Tamilnadu. Isolation of *Rhizobium* from root nodule was done by the method of Samosegaran and Hoben (1985). The reference salt tolerant *Rhizobium* strain was used for comparison. To confirm the salt tolerance of *Rhizobium* isolates, they were tested against different concentrations of NaCl salt. For this, YEMA medium supplemented with different concentrations of NaCl salt. Out of 7 salt tolerant isolates, 2 isolates were categorized under extremely salt tolerance.

Results and Discussion

Groundnut soil samples were collected from ten different locations in Cuddalore district of saline areas of Tamil Nadu and their physico-chemical properties were analyzed. Soils of saline areas of Tamil Nadu belonged to 3 textural types, Clay loam, sandy loam and loamy sand soil. The soil organic carbon contents were low, ranged from 0.52 to 0.88 %, soil pH ranged from 7.50 to 8.00, EC ranged from 0.49 to 0.90 dSm 1. The soil samples collected from Singarakuppam of

Cuddalore district recorded highest pH of 8.00 and highest EC of 0.9 dSm-1. Legumes have immense value due to their capacity to enhance soil fertility by fixing atmospheric nitrogen through the symbiotic relationship with rhizobia. However, salinity, water deficit and temperatures stress are serious threats to rhizobium-legume symbiosis. Thus, while strategies to improve legume production in saline environments include selection of host genotypes that are tolerant to high salt conditions, inoculation with salt-tolerant strains of rhizobia could constitute another approach to improve legume productivity under symbiosis (Keneni *et al*., 2010).

Table-1: Effect of inoculation of salt tolerant *Rhizobia* on Nodule Leghemoglobin of Groundnut var. VRI-3 in normal and saline soil

S.No.	Strains	Nodule leghemoglobin content (mg g^{-1} nodule)					
		Normal soil			Saline soil		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
1	Control	-	-	-	-	-	-
2.	GNR AU-1	0.630	1.265	1.135	0.610	1.130	1.025
3	GNR CD-4	0.820	1.385	1.245	0.710	1.380	1.187
4	GNR CD-8	0.784	1.270	1.140	0.620	1.200	1.050
SED		**0.023**	**0.0265**	**0.038**	**0.0175**	**0.0225**	**0.037**
CD(P=0.05)		**0.046**	**0.053**	**0.076**	**0.035**	**0.045**	**0.074**

Table-2: Effect of inoculation of salt tolerant *Rhizobia* on N content of Groundnut var. VRI-3 in normal and saline soil

S.No.	Strains	N content (mg $plant^{-1}$)					
		Normal soil			Saline soil		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
1	Control	34.20	105.00	210.00	33.80	83.18	190.05
2.	GNR AU-1	35.20	104.20	240.50	33.50	85.25	190.75
3	GNR CD-4	38.20	111.40	254.00	37.45	92.25	215.15
4	GNR CD-8	36.25	107.15	246.25	35.30	87.10	198.00
SED		**0.834**	**2.416**	**5.634**	**0.9605**	**2.013**	**5.041**
CD(P=0.05)		**1.668**	**4.832**	**11.268**	**1.921**	**4.026**	**10.082**

The salt tolerant Rhizobium sp inoculated plants recorded more leghemoglobin content and N ntent in all sampling periods, 30, 60 and 90 DAS. The salt tolerant Rhizobium sp GNR D-4 noculated groundnut plants gave maximum nodule leghemoglobin of 1.245 mg g-1 of nodule nd nitrogen content of 254.00 mg plant-1 in normal soils and nodule leghemoglobin content of .187 mg g-1 of nodule and nitrogen content of 215.15 mg plant-1 in saline soil at 90 DAS. The GNR CD-8 inoculated plants recorded leghemoglobin content of 1.140 mg g-1 of nodule and itrogen content of 246.25 mg plant-1 in normal soil and 1.050 mg g-1 nodule and 198.00 mg lant-1 in saline

soil. The effectiveness of the strains viz., reference strain, GNR CD-8 were poor when compared with GNR CD-4.

The rhizobial cells are known to respond to stress conditions by changing their morphology and size (Zahran, 1999). For instance, Kulkarni and Nautiyal (2000) found that in mesquite, the shape of temperaturestressed cells changed to spherical, compared with rod-shaped cells in non-stressed control. The decrease in N_2 fixation activity has been ascribed to a direct effect on nitrogenase or an indirect effect through decreases in leghaemoglobin content, respiration rate and malate concentration in nodules. Legumes and the process of nodule initiation are both more sensitive to osmotic stress than are rhizobia. Salt tolerant rhizobia might have the potential to improve yield of legumes under salinity stress. Numerous studies have shown that soil salinity decreased rhizobial colonization and nodulation and dramatically reduced N_2 fixation and nitrogenase activity of nodulated legumes.

Conclusions

Drought and salt-stress are the major constraints to plant productivity in environments and effective rhizobia to inoculate the leguminous crop plants could be an important strategy to improve the efficiency of *rhizobium*-legume symbiosis and thereby productivity. The results from this study showed that the rhizobia inoculated normal and saline soils can survive, grow and effectively nodulate their leguminous hosts even at high salt concentrations and identified the rhizobial strains through molecular characterization (16S-rDNA gene sequencing) and evaluate their growth performance, symbiotic efficiency and nodulating ability against other important environmental stresses such as temperature and pH.

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EFFECT OF *G. diazotrophicus* AND *G. fasciculatum* WITH GRADED LEVELS OF N AND P FERTILIZERS ON THE GROWTH AND YIELD OF SUGARCANE UNDER FIELD CONDITION.

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Abstract

Sugarcane belongs to the family Graminaea is the main source of sugar and one of the widely grown crop globally. In India, there are two different agro climatic regions for sugarcane cultivation namely tropical and sub-tropical. Tropical regions covered about 45% of the total sugarcane area and 55% of the total sugarcane production in the country. Where, the effect of G. diazotrophicus and G. fasciculatum was assessed on sugarcane yield. Hence the biofertilizers showed excellent alternative source for reducing the usage of chemical fertilizers. The yield of the sugarcane was tested by using various graded levels of N and P along with the biofertilizers. The present research elucidates that the reduced level of fertizers with G. diazotrophicus and AM fungi had a significant increase in yield of the sugarcane. The results of the present study clearly showed that by using G. diazotrophicus and AM fungi we could able to reduce usage of chemical fertilizers to the extend of 50%. These findings also helps to reduce pollution caused by excess amount of inorganic nitrogenous and phosphatic fertilizers.

Keywords: *G. diazotrophicus, AM fungi, Sugarcane and Biofertilizer.*

Introduction

Sugarcane, is one of the most important sugar rich, commercial crops in the world from which about 65% of commercial sugar was obtained. In India, sugarcane has been cultivated in about 3.8 to 5.04 million hectares with an annual production of 279 to 340 million tonnes of sugarcane in the past ten years and contributing around 7.5 per cent to the total agricultural productivity. The demand for sugar and other sweetening agents is steadily increasing day by day and the requirement has been estimated at about 625 million tonnes in 2020 AD, which is around 231 per cent of the present production level. Further the scope of expanding sugarcane cultivable area as compared to other irrigated crops are limited. Hence, increasing the total sugarcane production by augmenting per hectare productivity might be the viable option.

The natural availability of petroleum reservoir gets depleted year by year and in the future, world should face lots of difficulties for all types of petroleum products. Hence, it's our urgent need to find an alternative method to improve the availability of nutrients. In the present world we need to utilize biological sources or methods for the betterment of things, particularly for human beings and animals and by these ways methods we can able to minimize the chemical pollution in the surroundings as well as in the living systems. Even though different biological sources are available to improve the nutrients status in soil, among which one feasible way is to improve the availability of nutrients though biofertilizers.

G. diazotrophicus and AM fungal inoculation enhances the growth and development of sugarcane by fixing nitrogen in various parts of sugarcane via roots, stem and leaves along with

producing growth promoting hormones and by solubilizing, mobilizing phosphorus, potash and zinc compounds and protecting plants from stress and pathogens (Prabudoss and Stella, 2010).

Review of Literature

Interaction between soil bacterial population and AM fungi in rhizosphere soil

Mycorrhizal fungi interact with a wide range of other soil organisms, in the root, in the rhizosphere and in the bulk soil. The positive influence of the soil microorganisms in interaction with AM fungi on plant growth was reported by many workers (Bagyaraj, 1984; Boby *et al.,* 2008; Hu *et al.,* 2009).

Secilia and Bagyaraj (1987) estimated the population of total bacteria, nitrogen fixing bacteria and actinomycetes in the root zones of different AM fungi pot culture *viz., G. fasciculatum, G. margarita* and *Sclerocystis dussii*. They observed that the total bacteria, nitrogen fixing bacteria and actinomycetes were significantly greater in mycorrhizal pot cultures.

The most numerous and active populations of *Pseudomonas fluorescens* were found in the exorhizosphere, while the greatest development of *A. brasilense* occurred in the rhizoplane and in the endorhizosphere. AM fungi rapidly stimulated the development of the *P. fluorescens* population on the surface of the extra radicular mycelium. The endorhizosphere had the most favourable effect on *A. brasilense* in the endorhizosphere (Klyuchinkova and Kozhevin, 1990).

Krishnaraj and Sreenivasa (1990) isolated the oligotrophic bacteria associated with AM fungi cultures *viz*., *G. fasciculatum, G. mosseae* and *A. laevis* in Rhodes grass (Chloris gayana Kunth). They observed higher population of oligotrophic bacteria in association with AM fungal inoculum, which also varied in the number of associated bacteria. *G. fasciculatum* harboured the highest number of oligotrophic bacteria while *A. laevis* had the least counts of oligotrophic bacteria.

Rhizosphere microflora favoured AM fungal association and vice- versa in cassava root region. AM fungi in cassava plants with no phosphorus enhanced fungal, bacterial and actinomycetes population than the uninoculated plants. Maximum microbial populations were obtained at fourth month stage of the crop under partially sterile condition (Peretto *et al.,* 1995).

Increase in grain yield of various genotypes of wheat was higher when *G. fasciculatum* and *A. brasilense* were co-inoculated (Singh *et al.,* 1990b). The role of AM fungal spores on the infection of sweet potato plants by *G. diazotrophicus* was studied and interactions between these two indicated that AM fungi increased the translocation of *G. diazotrophicus* to aerial parts of the plant and *G. diazotrophicus* enhanced the sporulation of *G. clarum* in soil and within the roots (Paula *et al.,* 1991; Sathyan and Thangaraju, 2003).

Micro propagated sugarcane seedling inoculated with the AM fungal spores containing the diazotrophs contained much higher number of *G. diazotrophicus* in aerial parts than seedlings inoculated in vitro with the bacteria alone. When grown in non-sterile soil, the sugarcane seedling again showed the greatest colonization percentage of 65 per cent in the aerial parts after inoculation with AM fungal spores containing the diaztrophs (Paula *et al.,* 1991).

Krishnaraj and Sreenivasa (1990) observed that the *Capsicum annum* inoculated with AM fungi harboured number of bacteria in the endorhizosphere than the uninoculated plants.Jones and Sreenivasa (1993a) studied the effect of inoculation of *G. fasciculatum* and or phosphate solubilizing bacterium, *Pseudomonas striata* at four levels of two forms of P on rhizosphere microflora *viz.,* total bacteri, fungi and actinomycetes, *Azotobacter* and P solubilizer populations in sunflower (*Helianthus annuus* L.) at 30, 60 and 90 days after sowing. The population of these organisms increased significantly with the increase in the level of P and age of the host plant

inoculated of the organisms up to 60 days as compared to plants inoculated with either of them and later the microbial population decreased.

Materials and Methods

Biofertilizers

Nitrogen fertilization with biofertilizers was carried out in two phases viz., sett treatment and soil application according to the treatment based on the original recommendation of 10 packets ha^{-1} and 36 packets ha^{-1} respectively (each packet contains 200 g of lignite-based inoculants).

Diazotrophicus

Sett treatment: Setts were soaked in suspensions of the microbial inoculants [five packets (each packet 200 g) in 100 liters of water] for 2 hours.

AM fungi

Soil application: Sand mixed inoculants along with 20 – 50 AM spores/plant rhizosphere (one packet of 200 g mixed in 5 kg of sand) applied on 30th, 60th and 90th day after planting.

Observations at harvest

Milleable cane

The total number of milleable canes was counted and expressed as 000ha^{-1}.

Cane girth

Girth of canes was measured at the time of harvest and average recorded as girth of cane in mm.

Individual cane weight

At the time of harvest individual can weight were taken and expressed in kg.

Cane yield

Cane harvested from the subplot were weighed and expressed as t ha^{-1}.

Results and Discussion

Observation at the time of harvest

Milleable canes

At the time of harvest of sugarcane crop there was significant difference in the milleable cane among the treatments, 50 per cent N and P + *G. diazotrophicus* + AM fungi T_4 recorded increased number of milleable canes (118.00 '000 ha^{-1}) it was on par with 75 per cent N and P + *G. diazotrophicus* + AM fungi T_8 (118.00 '000 ha^{-1}) over absolute control (55.33 '000 ha^{-1}) and the values recorded in 50 and 75 per cent N and P + *G. diazotrophicus* were on par with one another (Table 1 and Fig. 1).

Individual cane weight

In individual cane weight the treatment receiving both 50 per cent N and P + *G. diazotrophicus* + AM fungi -T_4 (1.163 kg) and 75 per cent N and P + *G. diazotrophicus* + AM fungi (1.158 kg) showed an increase over 100 per cent N and P control (1.156 kg) and appreciable weight of cane also noticed in 50 and 75 per cent N and P + individual inoculation of *G. diazotrophicus* treatments (Table 1).

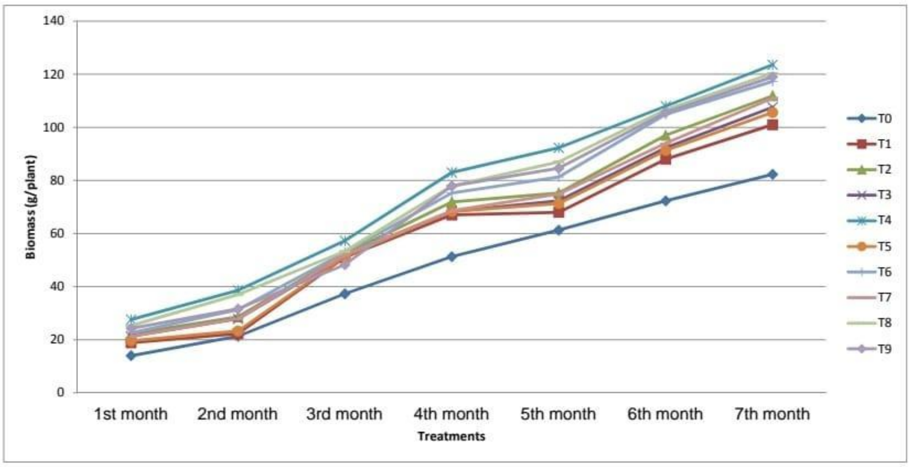
Cane yield

At the time of harvest a significant increase was observed in the treatments receiving 50 and 75 per cent N and P + *G. diazotrophicus* + AM fungi than other treatments and control. Maximum cane yield was noticed in 50 per cent N and P + *G. diazotrophicus* + AM fungi treatment T_4 (118.00 t ha^{-1}) it was on par with 75 per cent N and P + *G. diazotrophicus* + AM fungi treatment -T_8 (118.00) both were recorded significant values over 100 per cent N and P treatments (114.00 t ha^{-1}). 50 per cent N and P + *G. diazotrophicus* treatment was on par with 75 per cent N and P + *G. diazotrophicus* treatment and the values are tabulated in (Table 1).

Table 1: Effect of *G. diazotrophicus G. fasciculatum* with graded levels of N and P fertilizers on the growth and yield of sugarcane under field condition

Treatment	Milleable canes (000 ha^{-1})	Cane girth (mm)	Individual cane weight (kg)	Cane yield (t ha^{-1})
T_0 - Absolute control	67.90	68.90	0.752	55.00
T_1 - 50% N and P (control)	88.60	77.30	0.848	78.00
T_2 - 50% N and P + *G. diazotrophicus*	98.30	85.00	1.093	104.00
T_3 - 50% N and P + *G. fasciculatum*	95.00	82.00	0.938	91.00
T_4 - 50% N and P + *G. diazotrophicus* + *G. fasciculatum*	106.90	88.90	1.163	118.00
T_5 - 75% N and P (control)	93.30	80.90	0.933	85.00
T_6 - 75% N and P + *G. diazotrophicus*	98.90	85.30	1.094	104.00
T_7 - 75% N and P + *G. fasciculatum*	95.90	82.60	0.983	98.00
T_8 - 75% N and P + *G. diazotrophicus* + *G. fasciculatum*	106.90	88.60	1.158	118.00
T_9 - 100% N and P (control)	105.90	87.90	1.156	114.00
SE	0.16	0.09	0.02	0.27
CD (p = 0.05)	0.36	0.17	0.05	0.58

Fig. 1 Influence of *G. diazotrophicus* and *G. fasciculatum* with graded levels of N and P fertilizers on germination percentage and biomass of sugarcane under field condition



The result of the field experiments conducted at Vilagam village, Cuddalore District, Tamil Nadu, showed that *G. diazotrophicus* and AM fungi with 50 per cent and N and P fertilizers significantly influenced the growth and yield of sugarcane when compared to control. It showed suitability and N and P contribution of *G. diazotrophicus* and AM fungi to sugarcane (Boddey *et al.,* 1995; Sathyan and Thangaraju, 2003).

Significant increase in shoot and root length was observed in *G. diazotrophicus* treated plants. *G. diazotrophicus* in combination with AM fungi and 50 and 75 per cent N and P fertilizers could record shoot length on par with 100 per cent N. The possible reason for the increased growth could be the fixed N, solubilized P and growth promoting substances contributed by the endophyte (Cavalcante and Dobereiner, 1998; Sevilla *et al.,* 1998).

However, the root length and shoot length was also higher in *G. diazotrophicus* with 50 and 75 per cent N and P treated plants. It may be due to other growth promoting substance produced in large amount by

***G. diazotrophicus*.**

In the present of investigation, *G. diazotrophicus* in combination with AM fungi and 50 per cent N and P could record biomass more than 100 per cent N and P treatment.

G. diazotrophicus cells were re-isolated from rhizosphere soil of sugarcane from field trails in meager quantity and later no population was observed. This showed their inability and absence of survival in soil (Cavalcante and Dobereiner, 1988; Li and Mac Rae, 1991) and may be due to the higher pH of experimental plot (pH 8.1). More *G. diazotrophicus* population was recorded in those treatment receiving 50 per cent N and P +

G. diazotrophicus + AM fungi and 75 per cent N and P fertilizers and in concern with 100 per cent N and P treatment showed the inhibiting growth of *G. diazotrophicus* due to intensive fertilization. This is on par with the statement of Fuentes Ramirez *et al.* (1993); Muthukumarasamy *et al.* (1999) and Suman *et al.* (2008).

No significant difference was noticed in the germination per cent of sugarcane treatments. There was some positive result in the pot culture experiment conducted. Rajaram (1985) has reported that in sugarcane, development of shoot, root system takes place only after 35 days. From this, it is obvious that the vigour and viability of the setts have influence over germination per cent rather than the treatments.

Regarding the growth parameters like cane milleable, cane girth and cane yield the *G. diazotrophicus* + AM fungi and 50 and 75 per cent N and P treated plants performed better than the absolute and other controls. Thangaraju and Jayakumar (2002) and Muthukumarasamy *et al.* (1999) have recorded can height and cane yield of 50 per cent N and P + *G. diazotrophicus* on par with 100 per cent N and P treatment. In the present study, *G. diazotrophicus* treatment in combination of AM fungi with 50 per cent inorganic N and P fertilizers registered more number of milleable cane, cane girth and cane yield than 75 and 100 per cent N and P treatment. Inoculation of *G. diazotrophicus* + AM fungi could enhance the cane height, cane girth and cane yield. Hence possibility of saving 50 per cent of fertilizer N and P through *G. diazotrophicus* + AM fungi inoculation was reported (Thangaraju and Govindarajan, 2001). The present results were in accordance with the above findings.

In the present study, microbial treatments recorded increased sugar per cent, milleable canes, CCS per cent and purity over control. The slight increase in juice quality enhancement due to inoculation of *G. diazotrophicus* + AM fungi with 50 per cent N and P was earlier reported in some field experiments (Muthukumarasamy *et al.,* 1994; Thangaraju and Jayakumar, 2002; Prabudoss and Stella, 2010). From the results of the field experiment, the inoculation of *G. diazotrophicus* and AM fungi not only enhanced the growth and yield of sugarcane by consuming lesser amount of inorganic N and P fertilizers, but also increased the juice quality to certain extent. However, the treatments did not have much influence on juice quality of sugarcane. It is evident that juice quality is varietal character (Rajaram, 1985).

In the present study, the results of the field experiment revealed that the synergistic effects of combined inoculation of *G. diazotrophicus* and

G. fasciculatum resulted in increased plant growth, apart from growth enhancement. There was increase in plant nitrogen and phosphorus content up to 8th month of the crop. In general, there was decline in available soil nitrogen and phosphorus content during every month of the crop. It is furtherestablished that by dual inoculation to this crop with *G. diazotrophicus* and *G. fasciculatum* with 50 and 75 per cent N and P fertilizer application can able to reduce 25 to 50 per cent recommended N and P fertilizers without any reduction in the yield (Kaye *et al.,* 1984; Huang *et al.,* 1992; Mukerji and Ciancio, 2007; Singh *et al.,* 2007).

In the present study, the synergistic effects of combined inoculation of *G. diazotrophicus* and *G. fasciculatum* resulted in increased plant growth, biomass production, yield components, nutrient content (N and P) of plant, available N and P in soil, root colonization percentage of *G. diazotrophicus* and AM fungal spore population in sugarcane var. CoC 24.

It is evident that, interaction studies done in pots, showed significant difference between treatments. Hence, there is a need for extending these studies to confirm its efficiency in different field and environmental conditions by following the same treatment. The findings help to reduce N and P fertilizers up to 50 per cent without any reduction in the yield of sugarcane var. CoC24

Summary

The association between higher plant root and fungi (mycorrhizae) is wide spread in almost 80 per cent of the plant species. AM fungi is the most abundant kind of mycorrhizae found in association with every taxonomic group of plants and the list of species not infected is probably far shorter than the infected ones, these fungal associations are beneficial to crop plants in many ways, including enhancing the nutrient availability especially phosphorus, enhance water uptake and induce resistance against diseases and increases the yield of crop plants. *Gluconacetobacter diazotrophicus* is primarily responsible for biological nitrogen fixation and seems to contribute

substantially to nitrogen nutrition of the plants. Apart from nitrogen fixation, other properties associated with *G. diazotrophicus* are P solubilization, plant growth hormone indole acetic acid (IAA) production and suppression of red rot disease.

G. diazotrophicus and AM fungal inoculation enhanced the growth and development of sugarcane by fixing nitrogen in various parts of sugarcane via roots, stem and leaves along with producing growth promoting hormones and by solubilizing, mobilizing phosphorus, potash and zinc compounds and protecting plants from stress and pathogens.

In the field experiment, inoculation of *G. diazotrophicus and G. fasciculatum* with 50 and 75% N and P fertilizers had significant effect on growth and yield of sugarcane. However, germination per cent was not influenced by the treatments.

The results of the present study revealed that a minimum of 50 per cent N and P can be saved by co-inoculation of *G. diazotrophicus* and *G. fasciculatum*.

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ECO-FRIENDLY WRAPPING MATERIALS FOR CONSUMER PREFERENCE OF CHINA ASTER FLOWERS

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Abstract

The genus Callistephus derived its name from two Greek words 'Kalistos' and 'Stephos' meaning 'most beautiful' and 'a crown', respectively. Among the annuals, China aster is ranked third for popularity, after Chrysanthemum and Marigold. Almost in all states of India China aster has gained popularity for its beauty, variety of colours and longevity. Eco friendly wrapping materials are meant to decrease pollution in the environment as these are biodegradable. This experiment was conducted in the year 2021-22 in College of Horticulture, OUAT, and Chiplima. In this experiment different eco-friendly wrapping materials such as banana leaves, leaves of Butea monosperma, leaves of Shorearobusta and brown papers along with no wrapping and polythene with 3 replications in Completely Random Design.Regarding the consumer preference the consumers prefer flowers wrapped with leaves of Shorearobustafollowed by wrapped with banana leavesand Butea monosperma leaves due to its long shelf life.

Introduction

China aster (*Callistephus chinensis* (L.) Nees) belongs to the family Asteraceae and is native of China (Navalinskien *et al*., 2005). The genus Callistephus derived its name from two Greek words 'Kalistos' and 'Stephos' meaning 'most beautiful' and 'a crown', respectively. Cassini described China aster as *Callistephus hortensis*. It was first named by Linnaeus as Aster chinensis and later Nees changed this name to *Callistephus chinensis* (Janakiram, 2006). Among the annuals, China aster is ranked third for popularity, after Chrysanthemum and Marigold (Sheela, 2008). It is widely used as cut flower as well as loose flower in India. Almost in all states of India China aster has gained popularity for its beauty, variety of colours and longevity. Eco friendly wrapping materials are meant to decrease pollution in the environment as these are biodegradable. Successful inclusion of plant materials as wrapping materials for flowers can decrease cost for the farmers for which economic benefits can be gained by them.

Material and materials

Nursery raising of China aster was undertaken in pro trays and the seedlings were transplanted at 30 days of age. The transplanting of seedlings was done at a spacing of 30 cm × 30 cm accommodating nine plants per square meter area. The crop was fertilized with NPK 20:20:20 gram per meter square in the form of urea, DAP and MOP. The cultural operations like irrigation scheduling, pinching, weeding, staking and earthing up are done during the experimentation as and when required. The postharvest experiment was conducted in floriculture laboratory, College of Horticulture, OUAT, Chiplima in Completely Random Design with 6 treatments and 3 replications. Consumer preference was determined by scoring technique. Highly preferred is being 5 and lowest is being 1. Statistical analysis has done as per Gomez and Gomez (1984).

Result and discussion

Sl. No.	Treatments	Percentage of moisture loss	Percentage of weight loss	Shelf Life	Consumer Preference
1	Banana leaves	30.25	36.22	12.22	4
2	*Butea monosperma* leaves	36.78	44.65	11.45	3
3	*Shorearobusta*leaves	25.67	33.79	14.55	4
4	Brown paper	40.48	48.34	9.34	2
5	Polythene	58.76	66.34	5.35	2
6	No wrapping	60.1	67.33	3.23	1
	Mean	42.00667	49.445	9.356667	
	SD	14.44159	14.48797	4.316043	
	SE	5.895754	5.914691	1.762017	

Percentage of moisture loss and weight loss are highest is with no wrapping i.e 60.1% and 67.33% respectively followed by wrapped with polythene (58.76 and 66.34). The least Percentage of moisture loss and weight loss were observed in wrapping with *Shorearobusta*leaves (25.67 and 33.79 respectively) followed by wrapping with banana leaves (30.25 and 36.22 respectively) and supported by Dalbhagat*et al.* (2012).

The shelf life of flowers at 4 were highest when wrapped with leaves of *Shorearobusta* (14.55 days) followed by banana leaves (12.22 days) and leaves of *Butea monosperma* (11.45 days). Flowers wrapped with polythene has shelf life of 5.35 days and without wrapping flowers lasts upto3.23 days and similar results are supported by Sindhu *et al.* (2020) and Zosiamliana (2012).

Regarding the consumer preference the consumers prefer flowers wrapped with leaves of *Shorearobusta*followed by wrapped with banana leavesand *Butea monosperma* leaves due to its long shelf life. Similar type of results has been found in pomegranate by Arundhati *et. al.* (2019), in tuberose by Happy *et al*. (2021),

Farmers are also get benefitted out of the eco friendly wrapping materials as they need not to invest money on wrapping materials for packaging of flowers for transportation. The leaves are plentily available in forests and banana leaves are also available at their back yard as well as in field.

Conclusion

Eco friendly wrapping materials with banana leaves, leaves of *Butea monosperma*, leaves of *Shorearobusta*are suitable for wrapping of china aster flowers for remarkable shelf life. It is also preferred by farmers as leaves are readily available free of cost in jungles as well as their own orchards or backyards. It also decreases pollution in environment for better life.

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GREEN TECHNOLOGIES AND GOOD AGRICULTURAL PRACTICES IN GOA

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Abstract

Agriculture sector is the primary and indeed a very important sector, we all are dependent upon this sector for food, fodder, timber, and various other essentials. It is also a very significant contributor of the economy. Goa being in the tropical zone and near the Arabian Sea, has a hot and a humid climate for most of the year with moderate temperature variation between 17^o to 35^o C. Soils of Goa are mostly laterite (red coloured) with acidic soil and soil reaction. The major food crops grown in India are Paddy, cereals, pulses, oilseeds, sugarcane, and vegetables. The important horticulture crops of the state are cashew nut, coconut, arecanut, mango, banana, pineapple, and spices. There is a tremendous scope for the development and commercialization of the agriculture. In Goa it has been observed that the state of Goa is dependent on the neighbouring states for fruits, vegetables, and dairy. It is important to tackle the opportunity available in the agriculture sector which will indeed make the state of Goa self-sufficient on terms of agricultural produce, generate employment and shall indeed contribute significantly to the economy of the country.

Keywords: *Agriculture, Intercropping, Agro-Entrepreneur, Agro-Eco tourism, employment, organic farming*

Introduction

Goa is a small state located on the west coast of India, spread over in an area of 3,610 sq. km. The state is flanked in the east by Sahyadri Mountains and on the west with the Arabian sea. Goa is a rich treasure of biodiversity. Though tourism is on the forefront in terms of employment generation, agricultural sector has been providing livelihood support to almost 12 lakh people along with 15% to the state's income. The agriculture along with forests in Goa is instrumental in keeping Goa green and covers nearly 65% of the total area of the state. Agriculture is an important activity in the Goan economy. The region is endowed with a wide range of land forms, water bodies and favourable climate for the cultivation of cereals, plantation crops, varied fruits and vegetables etc. Goa is largely dependent on the neighbouring states like Karnataka and Maharashtra for day-to-day agricultural produce like vegetables, fruits etc. Along with achieving self-sufficiency in agriculture in state it is also important to assure higher net income to our farmers through introduction of effective and efficient techniques of farming and better utility of available resources in a sustainable way.

Review of Literature

Dessai.(2017). Found that apart from education of the farmers, various other factors such as land holdings, training, awareness as well as demonstration effects which influence agricultural production and productivity by influencing agricultural practices. Also, the findings suggested for the encouragement of the Agro-Tourism and organic farming.

D'Mello.(2019). Emphasised on the community farming in Goa as a tool against land conversion wherein it was found that undertaking the community agriculture can indeed turn to be profitable and can act as a tool against land conversion.

Gupta.(2012) . Found that proper sensitization and training to promote mechanization needed which will indeed boost the agricultural sector and shall yield huge returns. Also, the study focused on the importance of subsidized machinery and provisions for spares and servicing centres on farm training.

Kadam.(2019). Analysed the performance of agriculture in Goa. The objective of the study was to analyse the productivity of agriculture in Goa over a last 3 decades and possible causes in the changes in the net sown and cropped area. The study had relied primarily on secondary source which was obtained using articles, reports, and different websites etc. It was concluded that governments initiatives were good, but the degree of awareness among the farmers on various supportive measures and the need to adopt modern techniques of production was very low. The need of the hour is either one innovates or perish, but then a pragmatic approach will be required.

Pai Angle.(2018). Examined the awareness about the various agricultural schemes and incentives among the farmers in North Goa. The study identified the variety of crops grown and examined the source of finance by the agriculturist in North-Goa. The study involved Primary data and information collected through questionnaire which was given to 150 farmers. It also used secondary data collected through websites, books, booklets, citizen charters, newspapers. The study concluded that many agriculturists are carry on their ancestral business and earn a living from selling the produce. There are many schemes introduced by the government them. While some who know majority have not availed them due to of the agriculturist do not own lands/farms.

Upendra, and *et.al*. (2020). Studied the various applications of technology advancements in agriculture such as Digital Agriculture, Smart Farming or Internet of Agriculture Technology (IoAT), Crop Management, Weed and Pest control, Crop protection and big data analytics. The data was collected by conducting a survey on technology usage in agriculture. The study concluded that, In India a large number of people are engaged in agriculture and there is a gap between the farmers and technology. Governments have introduced various methods into agriculture to help the farmers to take the advantage of technology but there is a scope for user friendly easily understandable Agro - advisory systems to help farmers to take decision on crops to be sown. Also, at different levels of crops growth, these technological inventions should help farmers to extract best yield with reduced expenses. There exists a scope for research in this area.

Objectives of the study

1. To explore and analyse various opportunities available to the agricultural sector in terms of achieving sustainability with different technology
2. To study the scope of employment opportunities due the growth of agricultural.
3. To analyze the scope of Agri-preneurship in the state of Goa.

Limitations of the study

1. The research is limited to the state of Goa.
2. Due to time constraint only, a few farms were taken up for case study
3. The findings of this research can be applicable in the areas where similar type of physical and human traits prevails

Methodology

To present study is based upon secondary data and descriptive research. The secondary data was obtained through secondary sources like journals, articles, books, periodicals etc. Descriptive study was done considering 4 cases in Goa to understand the situation of agricultural development and to analyse its scope in the state of Goa.

Scope of the study

The study aims to understand the current situation of Agriculture in the state of Goa and tries to find out the various ways in which the agricultural sector can be developed. Various cases covered in the descriptive study were case of a software engineer, Ajay naik, Wakao foods, Rasraj farms and Tanshikar Spice farm.

Analysis

Lecetra Agri tech

"You are what you eat," they say. And that's what Ajay Naik, a Goa-based hydroponic farmer, believes in. After quitting his job and giving up his company, this software engineer decided to help farmers across India learn about hydroponics and the use of technology in agriculture. This Software Engineer Sold His Company to Start a Vertical Hydroponic Farm in Goa.For several years he had been noticing that many farmers' children prefer to go for an MBA or engineering degree these days instead of taking up farming. This is because agriculture is not always lucrative. But then, not many of us are focusing on the root of the system we live in – that is good quality food. Only when you have healthy food can you have a healthy country," says Ajay Naik, a Goa-based software engineer-turned into a hydroponic farmer. In times like these when the younger generation of farmers choose to opt for anything but agriculture, the case of Ajay would seem to be a paradox of sorts. The 32-year-old has turned to hydroponic farming to grow quality food because a lot of vegetables and fruits supplied to markets today are grown using harmful chemicals that are detrimental to health.

He believes that the right use of technology can improve a field's produce but the problem is that Indian farmers are already struggling with finances and are reluctant to take risks "They fear that if their investment in technology does not work out, it may lead to huge losses,". Ajay wants to change the equation by taking technology to as many farmers as he can. And that is where hydroponics comes into the picture.

Hydroponics is the process of growing plants in water with added nutrients without the use of soil.

"It was inspiring and motivated me to start a farm of my own as well. The fact that hydroponics involves technology, like developing a system for automatic circulation of water, controlling the parameters of temperature, humidity, etc. made me like it even more. I have been working in the IT industry for the past 10 years and I understand these things. In fact, it would have been difficult for me to understand traditional forms of agriculture," he says.

Fully equipped with the required knowledge, Ajay started his farm in Karaswada, Goa. With a team of six people and he now grows exotic vegetables like lettuce and salad greens using the Nutrient Film Technique (NFT). This is a hydroponic technique in which a shallow stream of water containing nutrients for plant growth circulates past the bare roots of plants in watertight cylindrical tubes also called channels. The water flows from one end and is re-circulated into the system from the other end, thus reducing water consumption by 80% when compared to traditional farming.

Since there is no soil involved in the process, there is no need for pesticides. Ajay has set up his system in a vertical farming model with racks that have seven levels to save space. He claims that this is Goa's first vertical hydroponics farm, which occupies an area of 150 square meters. He grows three tones of lettuce every month. The farm is set up in a controlled environment that enables me to grow exotic vegetables all-year-round without being dependent on the weather. In addition, he is now trying to convince other farmers to adopt this technology. He already started

showing the technique to farmers in vegetable expositions conducted by the agriculture department in different places in Goa. The Goa Agricultural department is also keen on collaborating with him so they can take it to more farmers. Other than this, he sells his produce to local vendors and in supermarkets. He is planning to grow bell pepper, cucumber, and strawberries too. In the future, he would also like to shift to other hydroponics techniques and increase the produce.

Producing food nowadays is becoming a real challenge. With the increasing population, water scarcity, and the ecological impact of transportation, hydroponics is the best choice for commercial as well as home-based farming. Among many advantages, hydroponics allows you to produce more (20 to 30%) high-quality vegetables and fruits, save on water and nutrient consumption, and grow fresh food everywhere – including sterile and unproductive lands, or in big cities and capitals. It helps cutting down on expensive intermediaries and shipping costs," he concludes.

Wakao Foods- an inspiration to take up Agro-Entrepreneurship

Goa-based Sairaj Dhond's Wakao Foods is a brand that sells pre-cooked meat alternatives without using artificial additives, all made of jackfruit. They offer Teriyaki Jack, Butter Jack, BBQ Jack, and Jack Burger Patty. As a child, Goa-native Sairaj Dhond recalls that he could not differentiate between chicken and jackfruit. Little Sairaj was not wrong as the texture of jackfruit, at a certain stage, is like meat.

It was this unconventional thought that led him to start Wakao Foods, a brand that sells pre-cooked jackfruit meat items like Teriyaki Jack, Butter Jack, BBQ Jack and Jack Burger Patty.

Sairaj's bootstrapped venture set up a supply chain with farming clusters. "My ultimate goal is to see every restaurant in India have a vegan menu beside the regular one," says the founder.

All products of Wakao have a shelf-life of 12 months and need not be refrigerated till opening of packets.

The brand has 27 offline stores, 30 restaurant partnerships and online sales all over the country. Additionally, it became the first startup of India backed by three female sharks on the reality show Shark Tank India, bagging a Rs 75 lakh deal.

RasRaj Farms

Goa based young couple Mr. Vandit Naik and Ms. Priyanka Naik, having an engineering degree in agriculture turned to the farming occupation. The farm named after the parents of Mr. Vandit Naik was developed into a lively farm venture by this couple with their dedication, patience, and hard work. Nowadays wherein many people feel that agriculture is not a profitable occupation, The RasRaj farm is a live example of the success and profitability in the agricultural and farming field. The couple did not only focus on the plantation of trees but have also given immense importance value addition activities which indeed boosted their income. They practice the intercropping method whereby their profits are increased, also they make use of the organic inputs and they produce their own organic inputs like- Panchgavya (organic fertilizer), compost, fertilizers etc. for their use and market the remaining outputs. They also practice apiculture which indeed boost the pollination and indeed acts as a source of side income. It is appreciable to see that these couple are working hard to preserve the indigenous varieties of the plants, fruits, vegetables, trees etc. of Goa. It was remarkable to see that they indeed make significant profit in this business.

Tanshikar Spice farm

Tanshikar's Working Spice Farm & Ecological Rest House is situated among the rainforest of Western Ghats at Netravali village, Sanguern taluka. The specialty of the Organic Farm is variety

of genuine spices grown in 25 Acres out of total 40 Acres land. Netravali is extremely popular for nature lovers as well as for adventures. One can discover the joy of the nature trek, bird watching trips, joy of bathing under waterfalls and relax in a company of nature, Adventure Sports. Since year 2005, Spice farm is open for the guests for the visit. With this encouragement a new Ecological Rest house has been built to serve you better and more naturally. TANSHIKAR SPICE FARM has received best organic farmer award from Prime Minister Narendra Modi on 11th of March 2016 in Delhi.

It is big reward as this farm is organic since its establishment and finally it got its reward. (It is also big achievement for CHINMAY and GAURI owners of farm who are doing farming for last 20 years and only guide the visitors of farm who come to understand about spices from different countries). Tanshikars farm also provides accommodation for Agro-eco tourism and indeed offer various accommodations like- Eco Rest Houses, Age old style cottages / tree houses, wooden houses etc. and along with accommodation it provides various other tourism activities like-cookery, adventure activities, jeep safari in wild life sanctuary, travelling on a waterfall, recreation, swimming pool, yoga etc. Tanshikar's farm is one of the largest farms and has indeed proved that farming can be very profitable and that agriculture and tourism both can go hand in hand and results in tremendous success in form of Agro-Eco Tourism.

Employment Opportunities

Agriculture sector has immense potential for the employability. There are various opportunities available in the agricultural sector in the fields of research and development, value addition chain, Agro- entrepreneurship, Agro-Eco Tourism, Organic farming etc. The need of the hour is to exploit the various opportunities available in this sector so that the youth can consider taking up employment in the agricultural sector too. As per the reports Goa's employment rate is around 13% which indeed is high, exploring the various opportunities for employment in the agricultural sector shall indeed help to reduce the employability and shall encourage the youngsters to work in this sector.

Agricultural Engineer

The job of an agricultural engineer is to improve current farming methods, design new equipment and machinery using computer aided technology (CAD) and also use data from the weather and GPS to advise farmers and businesses on land use, assessing the impact of the current processes on crops and the surrounding environment. An agricultural engineer might also get chance to supervise agricultural construction projects.

Agricultural Economist

The role of an agricultural economist is to apply microeconomic and macroeconomic concepts and theories to understand economic decisions, such as why shoppers make certain decisions about the food they buy and how the government chooses how to support farmers. Also they study various economic factors.

Agricultural Salesperson

The job of an agricultural sales person is to sell machinery, animal feed, fertilizers and seed to farmers. He has to have good knowledge about the products in order to advice the farmers on products. Also, the Agriculture sales person markets the agricultural produce and helps the farmers to market their products. Marketing of agricultural products plays a vital role in sales of the agricultural products.

Horticulture

Horticulture is the science of growing and cultivating fruits, vegetables, herbs, ornamental trees, and decorative flowers. Horticulturists aim at improving the quality, growth, nutritional value and yield of their produce. Horticulture indeed is a profitable activity. Horticulturist also works to maintain nurseries, greenhouses, orchards, and plantations, etc. Due to the rise in the demand for organic food, this sector is quickly picking up.

Dairy Technology

Dairy Technology is a field mainly concerned with the production and processing of milk. Professionals in this field manage the production of milk, including its collection and storage, and oversee its processing to make the milk fit for consumption. They also focus on activities like the packaging, storage and distribution of milk and its by-products, and ensure that nutritional and quality standards are met.

Poultry Farming

It involves raising domestic birds like chickens and ducks for procuring their meat and eggs. Majority of the poultry farms are involved in raising chickens due to their wide consumption both for eggs (Layer chickens) and meat (Broiler chickens). Individuals in this field have to manage a range of diverse activities like shed management, feed supply, nutritional standards of the produce, transportation of the products, etc.

Agronomy

It is the branch of agricultural science that deals with the study of crops and the soil in which they grow. Agriculturalist conduct research in various areas like restoration of soil fertility, preparation of good seedbeds, correct dates of sowing, proper methods of conservation, management of soil moisture and proper methods to control weeds and insects. Agronomists develop methods that help to improve the use of soil and increase the production of crops.

Agri-Business Management:

Agri-Business Management field essentially involves the management of all the business aspects related to agriculture. It includes handling activities relating to the manufacture and distribution of farm equipment and supplies; processing, storage & promotion of food, fiber and related agricultural products, etc. Professionals in this field are required to build a link between the farm and non-farm sectors for smooth movement of supplies.

Grafting and L-layering:

The Grafting and L-layering activity also has a great scope for employment. In, first the roots are formed on a stem of a mother plant and only after that the stem is cut off and is planted as a new plant. Plants grown from layering will fruit earlier than the ones grown from seeds. In grafting, a branch of a desired variety is grafted onto another plant. These indeed has a great scope for employment.

Apiculture

Apiculture activity indeed has great scope as in terms of earning supplement income and employment generation and improving nutritional intake of people. Though the honeybees are best known for the honey they produce, their economic role in nature is to pollinate hundreds and thousands of flowering plants.

Conclusion

The study shows that there is wide potential for the development of agricultural sector in the state of Goa. As observed by the case studies stated in the paper, there is a wide scope for the

youth to take up agriculture as their career option. The concept of Agro-entrepreneur has also gained popularity. Employment sector has a wide scope in terms of employment generation in various aspects like agricultural economist, processing of agricultural products, beekeeping (apiculture), grafting and L- layering etc. The cultivation of high value horticulture crops is gaining importance due to the better returns, lower risk and tolerance of these crops for part time farming. Agriculture mechanization has experienced a tremendous growth over the last few years.

The role of agriculture is not only limited to the production of the agricultural produce but has opened doors for various other opportunities like use of modern technology like the Vertical Hydroponic in agriculture, sustainability as well as commercialisation of agriculture. As people nowadays are very much concerned about the environment and environment protection is the main focus nowadays, this has indeed opened doors for Agro-Eco tourism, Organic and green farming techniques etc. It can be concluded that agriculture can be recognised as a lucrative opportunity. Looking at the demand for organic food, there is a huge scope for organic farming. New developments have opened up for new practices in agriculture.

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MICROGREENS – A COMPONENT OF SUSTAINABLE FOOD PRODUCTION

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Abstract

Over the years, compelled by the growing interest of society in healthy eating, fresh, functional and nutraceutical foods are in the rise. Speciality crop growers, researchers and extension specialists are utilizing the upcoming trends and opportunities to tap niche products. Both the consumption of fresh produce as well as the availability of fresh produce is constantly changing. Microgreens, also known as vegetable confetti is gaining tremendous importance in this aspect. Being the immature shoots of several vegetables, herbs and spices, they are harvested right after the emergence of true leaves within a duration of 2 weeks. They are consumed fresh as salad toppings in top-end restaurants. As the demand for these mini-leafy vegetables are in rise, suitable production aspects are required. Though several large-scale commercial production and marketing techniques have been discussed earlier, a need is created for indoor, rooftop and kitchen garden cultivation to enable these high value low volume greens be grown by the individual himself.

Keywords: *Microgreens, indoor, production, yield*

Introduction

The goal of sustainable development is aggravated through population explosion, increased erratic weather due to climate change, high and volatile food prices, constant monetary and economic crisis which consequently inflates the population leading to hunger and malnutrition. Tropical countries like India and Africa are the most affected by malnutrition and hunger. Increasing population and food demand for this surging human race have always been on debates. With population increasing to about 9 billion by 2030, the foremost concern for researchers is to serve food on plates of billions utilizing the limited resources. Therefore, burgeoning interest in fresh and functional foods coupled with proper health and longevity compels the demand of vegetable production at micro scale for improving the nutritional aspects of diet.

Microgreens are edible cotyledons and seedlings of many vegetables, herbs and flowers used to provide a range of colors, textures, and flavors to a variety of dishes (Xiao *et al.*, 2012, Pinto *et al.*, 2015, Mir *et al.*, 2017). Representing a new culinary trend, they are particularly popular with gourmet chefs around the world. They are larger than sprouts yet smaller than baby versions of vegetables. The functional components like antioxidants, phenolics, vitamins and minerals were found to be higher in these speciality crops compared to their vegetable mature counterparts. For production of mixed cropping, microgreens with similar growth rates are to be selected so that they can be harvested at once. In case of monoculture, they can be grown individually and mixed later. Some of the commonly cultivated vegetable greens include beet (Murphy *et al.*, 2010), cabbage, broccoli, radish (Xiao *et al.*, 2012), fenugreek, carrot, onion, palak, lettuce and amaranth. These nutrient dense foods which are obtained in a very short duration of less than a week within limited

space and reduced cost of production with increased returns are gaining momentum in market as well as our daily lives.

Table 1: List of Different Microgreens

S.no	Name	Botanical name	Family	Type of germination
1.	Amaranathus	*Amaranthus tricolor*	Amaranthaceae	Epigeal
2.	Carrot	*Daucus carota*	Apiaceae	Epigeal
3.	Spinach	*Spinacia oleraceae*	Amaranthaceae	Epigeal
4.	Beetroot	*Beta vulgaris*	Amaranthaceae	Epigeal
5.	Onion	*Allium cepa*	Amaryllidiaceae	Epigeal
6.	Fenugreek	*Trigonella foenum-graucum*	Fabaceae	Epigeal
7.	Cabbage	*Brassica oleracea* var *capitata*	Brassicaceae	Epigeal
8.	Cauliflower	*Brassica oleracea* var *botrytis*	Brassicaceae	Epigeal
9.	Broccoli	*Brassica oleracea varitalica*	Brassicaceae	Epigeal
10.	Radish	*Raphanus sativus*	Brassicaceae	Epigeal

Materials and Methods

Microgreen selection and production:

Ten culinary greens of different families were taken up for study. These include amaranthus, beetroot and spinach (Amaranthaceae), carrot (Apiaceae), cabbage, broccoli, cauliflower and radish (Brassicaceae), Fenugreek (Leguminaceae) and Onion (Amaryllidiaceae). The study was conducted at indoor conditions in Pondicherry UT, India. A highly aerated and good moisture holding cocopeat substrate was used as a growing media. The experimental design adopted was Completely Randomized Block Design (CRD) replicated thrice. Plastic trays of 18 x 15 x 6 cm were taken for cultivation. The trays were filled with media to about three-fourth, seeds of 3g for all the microgreens, except amaranthus were 1g of seeds were sown densely over the trays and covered with a thin layer of media. Later the trays were sprayed with water to enable germination. Just as the greens have attained their respective heights, they were harvested with the help of sharp scissors.

Parameters recorded

Various growth and yield parameters that were observed include seed soaking, days to first germination (days), germination percentage (%), shoot length (cm), vigour index, fresh weight (g), dry weight (%) and days to harvest (days). Seed soaking was determined based on the nature of the seed. Days to first germination was recorded as the number of days required for the seeds to initiate seedling emergence. Germination percent was calculated as the number of seeds germinated to the total number of seeds sown. Shoot length was obtained by measuring the length of from the base to the tip of leaves. The multiplication of seedling height with germination percentage resulted in vigour index. Fresh weight was calculated based on the weight of seedlings in individual trays. Days to harvest was recorded as the number of days taken for microgreens to mature from the date of sowing.

Statistical analysis

The data was converted to mean values for all the microgreens and was statistically analyzed using DSAASTAT tool. For treatments showing significance, critical differences were worked out at five percent probability level.

Result and Discussion

All the greens taken up for study were exposed to seed soaking except amaranthus, broccoli, cauliflower, and radish. With respect to days to first germination, fenugreek germinated earliest at 2.08 days, followed by radish (2.16 days) and amianthus (2.51 days). The earlier emergence of fenugreek seedlings might be due to advanced seed metabolism which sped up germination when the seeds were soaked overnight (Ashraf and Foolad, 2005). Beetroot was the last to germinate, this might be because of the nature of beet seeds. The seedball consisting of multigerm are wrapped in a woody pericarp having impervious sclerenchyma that restricts water and oxygen uptake by the enclosed seeds (Chomontowski and Podlaski, 2020). Germination percentage, shoot length and vigor index were found to be maximum in radish with 98.15 %, 7.45 cm and 733.53 respectively. Onion had the least germination percent (74.21 %). Similar reports for maximum germination was observed by Ramya *et al.* (2020). Carrot had a minimum shoot length (4.26 cm) and least vigor index (382.46), which was similar to the findings of Ghoora and Srividya,(2018).

For fresh weight and dry weight, maximum fresh weight and yield per tray was recorded in radish (63.47 g/tray) with a dry weight at 4.76 %. Beetroot, contrary to this had the lowest fresh weight of 10.09 g/tray with a dry weight of 0.91%. Radish microgreens were said to have maximum number of plants per tray as well as yield per tray as reported by Ramya *et al.* (2022). Highest total fresh yield in radish was also reported by Ghoora and Srividya, 2018. Dry weight was at its least in beetroot, indicating the higher moisture content of the produce. It may be concluded that high dry matter is associated with higher shelf life (Manzocco*et al.*, 2011).

Table 2: Performance of different microgreens for Growth and yield parameters

S.No	Microgreen	Seed soaking	Days to first germination (days)	Germination percentage (%)	Shoot length (cm)	Vigour index	Fresh weight (g/tray)	Dry weight (%)	Days to harvest (days)
1.	Amaranathus	x	2.51	94.35	6.32	596.29	48.59	3.65	10.34
2.	Carrot	✓	5.70	89.78	4.26	382.46	52.56	4.22	14.31
3.	Spinach	✓	2.80	97.64	4.52	441.33	13.05	1.10	12.56
4.	Beetroot	✓	6.28	91.74	5.78	530.26	10.09	0.91	14.89
5.	Onion	✓	5.20	74.21	6.05	448.97	23.51	1.61	16.00
6.	Fenugreek	✓	2.08	96.78	5.79	560.36	43.38	3.28	13.21
7.	Cabbage	✓	2.72	89.88	6.23	559.95	27.18	2.57	9.76
8.	Cauliflower	x	2.57	80.65	7.32	590.36	31.94	2.50	11.78
9.	Broccoli	x	2.64	83.25	6.20	516.15	36.17	2.68	10.78
10.	Radish	x	2.16	98.15	7.45	733.53	63.47	4.76	8.62
CD (p=0.05)		-	0.24	6.78	0.81	80.82	2.51	0.24	1.45
S. Ed		-	0.12	3.38	0.40	40.41	1.25	0.12	0.73

Microgreens are harvested when the desired height is attained and first set of cotyledon leaves and true leaves appear. The time from seeding to harvest greatly varied for crops from 1 to

3 weeks (Allende *et al.*, 2004; Xiao *et al.*, 2014b). These are ready for harvest when they reach the first true leaf stage. Radish microgreens matured earlier and were harvested at 8.62 days, followed by cabbage (9.76 days). Onion had a delayed harvest of 16 days. According to this study, radish, fenugreek, spinach, amaranthus, cabbage, cauliflower and broccoli were fast growing and were harvested between 9 – 13 days; whereas carrot, onion and beetroot being slower at growth were harvested at about 14 – 16 days.

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ARTIFICIAL INTELLIGENCE IN FARM EDUCATION, RESEARCH AND EXTENSION

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Abstract

The deployment and use of artificial intelligence tools in our farm sector is going to revolutionize our farm production, marketing, and value addition processes. It is also going to improve the effectiveness; efficiency of our supply chains meeting the needs and aspirations of our raising population and needs of our industry. So, the need of the hour is educate our farm professionals use artificial intelligence in farm research and extension to address the present day challenges of climate change, price fluctuations in farm markets and malnutrition issues plaguing our farm sector in short and long terms through sustainable farm production. Our Policy Planners, Farm Scientists, Extension Workers, and District Administrators need to integrate and work together in deploying artificial intelligence tools in the best interest of our nation soon.

Introduction

The evolution, growth, and development of Artificial Intelligence (AI) tools dates to 1996 when technology started thinking and acting rationally like human beings with a super charged processing power. Within a span of 15 years machine learning, national language processing and predictive analysis has become the order of the day with technical inputs playing a important role in decision making. By the year 2019, super powers started competing to gain technological supremacy and with the evolution of facial recognition technologies, predictive analysis of AI has resulted in its revolutionary application in all walks of life. However, the use of data as a building block or as new oil in making informed decisions is initiating a global technological revolution across the world. More transactions, tasks employing skilled and unskilled labour are going to be replaced over a period and it is estimated that by 2034-2040 ie., within the next 15 years more than 50 per cent of jobs will be automated in us. The deployment of facial recognisation technologies, use of natural language processing, using Artificial Intelligence tools are going to generate huge quantum of data and business with wide range of applications resulting in displacement and deployment of large population dependent on farming and allied sectors. These new technological interventions are going to redefine our farm operations soon. The disruptions in labour force with low employment rates for blue collar workers in the net labour force is also sure to create lot of socio- economic problems in developing countries across the world. On the others hand data, privacy issues, ethical governance also needs to be regulated and skilling for future programme as developed in Singapore has become the new order of the day across the world. So, in this context, with our government going ahead with 5G services across our nation soon the building of new apps with low code/No code platforms are empowering small and medium enterprises to address their business needs and development challenges. The need for more than 500 million apps to be developed in the next few years will allow people with little or no knowledge of coding to build

software with a modular approach and a friendly graphical user interface. This needs to be simply dragged and dropped into software components all of which will be visually represented to make an app like a power point presentation. The advancements in Artificial Intelligence have played an important and critical role in the making of Low code/ No code platforms make it perform cumbersome and error prone tasks like data mappings, object understanding across data events and massages to be automatically understanding and mapped with less human interventions. A recent report by Nasscom suggests that the global NC/LC industry is expected to grow at a CAGR growth of 28.1 % from 2021 to 2025 with massive acceptance and evolution of digital platforms across sectors. This development is also going to fundamentally reduce the amount to build software when the process gets automated.

Artificial Intelligence in Farm Education

The development and use of Artificial Intelligence tools, devices, systems, and process at the field level warrants the creation and need for educating farm students, professionals, and farm workers in this new rising sector. A new Dev Rel or Developer relations as a process that assist industries or companies or institutions that assists them to work with software developers. Playing an interdisciplinary role, within the interaction of product engineering and marketing it has four main responsibilities of creating educational content and resources, developing in person workshops, Building, and managing community programmes with brand building awareness and affinity as main roles. These initiatives will revolutionize our farm sector with new technological advancements and improvements over a period giving rise to growth of significant number of enterprises leveraging on the use of low code services to derive more benefits. These platforms also assist in building apps 20 X faster with 100X less code soon. So, our present-day farm, education needs to undergo metamorphosis to meet these new challenges or developments which are going to address the present and future needs of our farm markets.

Artificial Intelligence in Farm Research

Our rising population in our nation with new needs, aspirations and lifestyles are bringing new sets of challenges and opportunities for our farm sector. The absence of more cultivable land and productive resources has resulted in the need for deployment of new farm revolutionary technologies to meet this rising farm production demand. The need for lab grown meat, safer GM foods, ability to tap nuclear energy and utilize solar energy replacing fossil fuels is the new order of the day. This has resulted in the growth and rise of many new farm startups, big investments by technology behemoths such as IBM and Google to make quantum computing, use of CRISPR-CAS technologies to create new farm products and services. This is going to revolutionize our farm production systems soon. On the other hand with income, innovation and integration (The Three Is of farming) holding the key for this new age agriculture, ensuring stability and support to our small and marginal farmers with disruptive modules are also the new order of the day. Keeping these issues in focus, we also need to use models based on IFS focused up crop- livestock and aquaculture tested across our Indian villages. Annamalai University demonstrated Integrated Farming System model developed by Prof R M Kathiresan and his team members has increased annual increase in net returns per household to a tune of Rs. 33,000- 50,500 per hectare from rising two and three crops respectively deploying 11.4- 19.6 tonnes of poultry droppings per hectors and pest suppression ranging from 17- 27 per cent. This if deployed to ensure food and nutritional security across rice growing regions of the world is going to change the face of our farm sector soon. Being sustainable in nature, using low-cost inputs, promoting conservation and judicious use of our

available farm resources, this initiatives coupled with AI tools are going to assist us in achieving higher production, productivity, marketing and efficient value addition of our farm produce.

Deploying Artificial Intelligence in Farm Extension Activities

The use of drones in carrying out our day-to-day farm operations, the deployment of Aadhar based payment interfaces, facial recognisation technologies in the effective utilization of human resources, new cloud mechanism for storing and retrieving large quantum of farm data across our geographies are revolutionizing our farming sector in a major way. Farm extension also needs to remain a major stakeholder to these new mechanisms or advancements. With faster processing of data on various farm productive indicators, the need of the hour is to utilize the services and products of AI technologies to meet the rising needs of farm enterprises which are suppliers of raw materials or products to our domestic and international retail chains or FMCG industries. With climate change issues, Price fluctuations in farm markets and malnutrition issues plaguing our nation at large, the need of the hour is to effectively use modern advanced technologies which are highly productive, low cost in nature, scalable, effective, and efficient to meet the development needs of our farm communities in meeting this new set of challenges. The opportunities on using this advanced farm technologies will also result in creating more job opportunities in rural and semi urban markets of our nation across geographies. The rural and urban youth will be the main beneficiaries of this new development process and assist our nation to achieve sustainable development goals soon.

Conclusion

The deployment of Artificial Intelligence in farm education, research and extension is going to revolutionize our farm sector in a big way. With climate change issues, Price fluctuations in farm markets, malnutrition issues plaguing our farm sector and nation, the need of the hour is to use such innovative technologies which are eco- friendly, scalable, low cost, effective and efficient to meet our development and market needs. Our Policy Planners, Farm Scientists, Extension Professionals, District Administrators need to work together to integrate and use artificial intelligence tools, products and services in our farm sector to meet our food production needs, address malnutrition and climate change related issues, Price fluctuations in farm markets at the earliest in the best development interest of our nation.

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EFFECT OF ORGANIC INPUTS ON YIELD AND QUALITY OF SACRED BASIL (*Ocimum sanctum* L.)

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Abstract

Sacred basil (Ocimum sanctum L.) is one of the important medicinal and aromatic plant grown in India from the time immemorable. It is otherwise known as "Queen of herbs" and is most sacred herb of India. It yields many essential oils and aroma chemicals and find diverse uses in perfumery and cosmetic industries as well as indigenous system of medicine. The use of inorganic fertilizers has their negative effects on crop and soil health as well as quality of plant. Therefore, the application of organic inputs is another way of applying nutrients to the plants. Hence, the present study was initiated to evaluate the effect of organic inputs on yield and quality in sacred basil (Ocimum sanctum L.). The experiment was laid out in randomized block design with ten treatments and replicated thrice. The treatments consisted of different organic inputs viz., FYM (25 t ha^{-1}) and vermicompost (5 t ha^{-1}) as basal application, panchagavya (3%) and seaweed extract (2%) as foliar application at 40, 55, 70 days after planting. The yield attributes and quality attribute were recorded at the time of harvest. The results of the experiment revealed that the yield attributes like fresh herbage yield (per plant and per hectare) and dry herbage yield (per plant and per hectare) and the quality attribute like essential oil content were significantly influenced by application ofFYM (25 t ha^{-1}) + vermicompost (2.5 t ha^{-1}) + panchagavya 3 % + seaweed extract 2 % when compared toothers in Ocimum.

Introduction

Basil is the popular name given to any aromatic herb belonging to the genus *Ocimum*. The genus *Ocimum* belonging to the family lamiaceae is an extremely versalite group consisting of about 160 species with geographical distribution all over the tropical, subtropical, and warmer parts of the temperate regions. Sacred Basil or Holy Basil botanically called as *Ocimum sanctum* L and it is considered as "Queen of Herbs". It is a tropical plant. It is native to the Indian subcontinent and wide spread as cultivated plant throughout the south East Asian tropics. The essential oil found in tulsi is Eugenol (1-hydroxy-2 methoxy-4 allylbeneze). The plant contains mainly phenols, aldehydes, tannis, saponins and fats. In India, Basil is cultivated in about 3000 ha mainly in the states of Uttar Pradesh, Haryana, and Punjab with production of 350 tonnes of basil oil. Uttar Pradesh account for more than 80% of the total area under cultivation (Rajit Ram *et al*.,2019).

The health benefits of holy basil or tulsi include oral care, relief from respiratory disorders, fevers, asthma, lung disorders, heart diseases and coughs. Plant leaves are used to make "Tulsi Tea" and in production of oil. The oil is applied to reduce joint pains, inflammations, and body rashes. Recent studies show that is also helpful in inhibiting growth of HIV and carcinogenic cells (Kalyankumar*et al.,* 2012). It is erect, much branched, soft hairy, fragrant, and erected plant attaining a height of about 30-90cm in length supported by a square stem that is hairy and lignified at the base.

Organically grown sacred basil has more demand in pharmaceutical industry as it produces chemical free drugs and it is also used daily in medicines to cure many ailments and improve the quality of essential oil, hence there is a strong need to boost the organic production of sacredbasil. Organic farming enhances soil organic carbon, available phosphorus content and microbial

population / enzymatic activity of soil thus making it sustainable for organic medicinal plants production. Owing to positive influence of organic components medicinal plants cropping system, it is therefore, be assumed that those farmers who adopted organic management practices found a way to improve the quality of their soil, or at least stemmed the deterioration. The system is became long term productive by protecting soils and enhancing their fertility ensuring productive capacity for future generations.

Although chemical fertilizers are one of the factors to maintain soil fertility, excessive application of them has negative effect on physical, chemical, and biological process of soil and increase the probability of soil erosion. The use of biological manure is regarding as an effective way for maintain soil quality that cause increase useful reactions between plant and microorganism in rhizosphere and increase plant ability for absorb minerals.

Thus, organic manure application such as Farm yard manure, vermicompost and formulations such as panchagavya, seaweed extract not only can maintain the health of environment but also increase the quality and stability of yield especially in medicinal plants.

In view of the above the present study on the "Effect of organic inputs on yield and quality in sacred basil (*Ocimum sanctum* L.)" is taken up for sustainable cultivation.

Materials and Methods

The present study entitled "Effect of organic inputs on yield and quality in Sacred Basil (*Ocimum sanctum* L)" was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalainagar. The experiment was laid out in randomized block design with ten treatments and replicated thrice. The treatments consisted of different organic inputs *viz.*, FYM (25 t ha^{-1}) and vermicompost (5 t ha^{-1}) as basal application, panchagavya (3%) and seaweed extract (2%) as foliar application at 40, 55, 70 days after planting. The seedlings of sacred basil about 10cm height were collected from nursery which is in salem. The experimental field was ploughed thoroughly to break the clods and weeds & stubbles were removed and brought to fine tilth. Then ridges and furrows were made andthe land was converted into small plots, each measuring the spacing of 2m x 2m with bunds of 30 cm width and 25 pits were made per plot. The healthy and uniform sized plants were selected and planted in the experimental plots as per the treatments. Light irrigation was given to the plots before and after planting and required plant population was maintained by gapfilling. The recommended dose of fertilizer for sacred basil is 120:60:60NPK kg ha^{-1}. The fertilizer applied in the form of urea, single super phosphate and murate of potash. The half dose of nitrogen and full dose of phosphorous and potassium were applied as basal before planting. The remaining nitrogen is applied in two split doses at 45 and 60 days after planting. The recommended dose of FYM (25 t ha^{-1}) and vermicompost (5 t ha^{-1}) were applied to the allotted treatments at the time of plot preparation. The Panchagavya was given as foliar spray at the rate of 3 % after 40, 55 and 70 days after planting. The sea weed extract was applied at the rate of 2 % foliar spray after 40, 55 and 70 days after planting. The yield attributeslike fresh herbage yield (per plant and per hectare) and dry herbage yield (per plant and per hectare) and the quality attribute like essential oil content were recorded at the time of harvest. The data recorded were subjected to statistical analysis by adopting the standard procedure of Panse and Sukhatme (1985).

Results and Discussion

The important attributes related to yield *viz.,* fresh herbage yield (per plant and per hectare) and dry herbage yield (per plant and per hectare) were significantly affected by the application of various organic inputs.

The herbage yield was recordedat two different growth stages of the plant. The highest fresh herbage yieldper plant (Table 1) and per hectare (Fig.1) and dry herbage yield per plant (Table 2), and per hectare (Fig. 2) were observed in (T_{10}) FYM 25 t ha^{-1}+ vermicompost 2.5 t ha^{-1} + panchagavya 3% + seaweed extract 2% which was followed by (T_9) FYM 25 t ha^{-1} + vermicompost 2.5 t ha^{-1} + seaweed extract 2%. The least values for the above traits were recorded in treatment (T_2) FYM 25 t ha^{-1}. The results are in accordance with Bhaba Prashad Kalita *et al.* (2018) in tulsi, SadashivNadukeri *et al.* (2014) in coleus, Shahira *et al*. (2015) and Srinivas *et al*. (2017) inlemongrass.

Incorporation of FYM increased the yield parameters might be due to faster in cell division, multiplication, and cell elongation in meristematic region of the plant due to production of plant growth substances (Smitha *et al*., 2019).

However, the basal application of vermicompost increased the plant growth and yield due to the presence of nutrients such as N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B which has a positive effect on plant nutrition, photosynthesis and chlorophyll content of the leaves leads to improve the plant quality (Margit Olle, 2019).

Futher, foliar spraying of seaweeds extracts increased the growth and crop yield due to presence of macro and micro nutrients, amino acids, vitamins, cytokinins, auxins, and abscisic acid (ABA)-like growth substances affect cellular metabolism in treated plants (Wajahatullah Khan *et al.*, 2009). Meanwhile, seaweed contributes to the best development of plants and reduces the risk of biotic and abiotic stress and can be used as alternative to chemical fertilizers known to be harmful for health and the environment (Chbani *et al.*, 2015)

Generally, the nutrients applied in the form of foliar spray are in readily available form and it was noted that the nutrients in liquid forms can be taken up by the plants quickly and improved the photosynthetic efficiency of individual plants thereby increasing the yield. Presence of high organic matter, micro and macro nutrients and growth promoting activity (greater movement and availability of phosphorus and micronutrients to the plant) might also be a possible reason for higher yield. Similar results are in accordance with the findings of Munnusingh and Ramesh (2002) in sweet basil and Padmapriya *et al.* (2010) ingymnema.

In the present investigation, application of FYM 25 t ha^{-1}+vermicompost 2.5 t ha^{-1} + panchagavya 3% + seaweed extract 2% (T_{10}) recorded the maximum essential oil content (Table 2) followed by (T_9) FYM 25 t ha^{-1} + vermicompost 2.5 t ha^{-1} + seaweed extract 2%. The least value was recorded in treatment (T_2) FYM 25 t ha^{-1}. The results are in accordance with findings of VeerananUthirapandi*et al.* (2018) in sacred basil andBohloulAbbaszadeh*et al.* (2016) in lavender, The organic fertilization stimulated the photosynthetic activity in plants leads to more accumulation of essential oil via higher density of oil glands due to the improvement in biomass yield (Jalil Dehghan Samani *et al.*,2017).

Conclusion

Based on the findings of the present investigation, it can be concluded that the combined application of FYM 25 t ha^{-1}+ vermicompost 2.5 t ha^{-1} + panchagavya 3% + seaweed extract 2% can be considered as best organic combination to obtain maximum yield good quality herbage yield from sacred basil in economically profitablemanner.

However, application of organic manures increased the growth of plant, maintain the quality of plant, soil fertility and better improvement in the nutrient availability which gives the sustainable yield. Organic manures are eco- friendly and at the same time safe to the nature.

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Table 1: Effect of organic inputs on fresh herbage yield plant^{-1} in sacred basil (*Ocimum sanctum* L.)

Treatments	Fresh herbage yield (g plant^{-1})		
	I Harvest	II Harvest	Mean
T_1 - FYM 25 t ha^{-1} + RDF (120:60:60 NPK kg ha^{-1})(control)	354.12	379.85	366.98
T_2 - FYM 25 t ha^{-1}	112.56	124.12	118.34
T_3 - Vermicompost 5 t ha^{-1}	154.82	162.39	158.60
T_4 - FYM 25 t ha^{-1} + Panchagavya3%	192.58	202.45	197.51
T_5 - FYM 25 t ha^{-1} + Seaweed extract 2%	234.65	249.26	241.95
T_6 - Vermicompost 5 t ha^{-1}+ Panchagavya 3%	198.26	209.21	203.73
T_7 - Vermicompost 5 t ha^{-1}+ Seaweed extract 2%	241.65	255.34	248.49
T_8 - FYM 25 t ha^{-1} + Vermicompost 2.5 t ha^{-1} + Panchagavya 3%	275.86	294.85	285.35
T_9 - FYM 25 t ha^{-1} + Vermicompost 2.5 t ha^{-1} + Seaweed extract 2%	311.23	333.65	322.44
T_{10} - FYM 25 t ha^{-1}+ Vermicompost 2.5 t ha^{-1} + Panchagavya 3% + Seaweed extract 2%	346.26	372.13	359.19
S. Ed	**4.61**	**4.91**	
CD (P = 0.05)	**9.70**	**10.33**	

Table 2. Effect of organic inputs on dry herbage yield (g plant^{-1}) in sacred basil (*Ocimum sanctum* L.)

Treatments	Dry herbage yield (g plant^{-1})		
	I Harvest	II Harvest	Mean
T_1 – FYM 25 t ha^{-1}+ RDF (120:60:60 NPK kg ha^{-1})(control)	95.33	103.59	99.46
T_2 – FYM 25 t ha^{-1}	63.18	74.25	68.71
T_3 – Vermicompost 5 t ha^{-1}	70.08	79.65	74.86
T_4 - FYM 25 t ha^{-1} + Panchagavya3%	74.86	84.80	79.83
T_5 – FYM 25 t ha^{-1} + Seaweed extract 2%	79.99	89.71	84.85

T_6 – Vermicompost 5 t ha^{-1}+ Panchagavya 3%	75.43	85.37	80.40
T_7 – Vermicompost 5 t ha^{-1}+ Seaweed extract 2%	80.45	90.25	85.35
T_8 – FYM 25 t ha^{-1} + Vermicompost 2.5 t ha^{-1} + Panchagavya 3%	85.40	95.39	90.39
T_9 – FYM 25 t ha^{-1} + Vermicompost 2.5 t ha^{-1} + Seaweed extract 2%	90.52	98.51	94.51
T_{10} – FYM 25 t ha^{-1}+ Vermicompost 2.5 t ha^{-1} + Panchagavya 3% + Seaweed extract 2%	94.77	103.07	98.92
S. Ed	**1.47**	**1.64**	
CD (P = 0.05)	**3.09**	**3.45**	

Table 3: Effect of organic inputs on Essential oil content (%) in sacred basil (*Ocimum sanctum* L.)

Treatments	**Essential oil content %**		
	I Harvest	**II Harvest**	**Mean**
T_1 - FYM 25 t ha^{-1} + RDF (120:60:60 NPK kg ha^{-1})(control)	0.36	0.32	0.34
T_2 - FYM 25 t ha^{-1}	0.18	0.16	0.17
T_3 - Vermicompost 5 t ha^{-1}	0.22	0.19	0.20
T_4 - FYM 25 t ha^{-1} + Panchagavya3%	0.27	0.23	0.25
T_5 - FYM 25 t ha^{-1} + Seaweed extract 2%	0.31	0.27	0.29
T_6 - Vermicompost 5 t ha^{-1}+ Panchagavya 3%	0.28	0.24	0.26
T_7 - Vermicompost 5 t ha^{-1}+ Seaweed extract 2%	0.32	0.28	0.30
T_8 - FYM 25 t ha^{-1} + Vermicompost 2.5 t ha^{-1} + Panchagavya 3%	0.34	0.30	0.32
T_9 - FYM 25 t ha^{-1} + Vermicompost 2.5 t ha^{-1} + Seaweed extract 2%	0.39	0.35	0.37
T_{10} - FYM 25 t ha^{-1}+ Vermicompost 2.5 t ha^{-1} + Panchagavya 3% + Seaweed extract 2%	0.41	0.37	0.39
S. Ed	**0.006**	**0.005**	
CD (P=0.05)	**0.012**	**0.011**	

EFFECT OF ORGANIC AND CHEMICAL FERTILIZER ON SEED YIELD, OIL CONTENT AND PROTEIN YIELD OF SUNFLOWER

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Abstract

Field investigation was carried out at the Annamalai University, Experimental Farm, Department of Agronomy, Annamalai Nagar, Tamil Nadu to study the Effect of organicand chemical fertilizer on seed yield, oil content and protein yield of sunflower. The Experiment was laid out in randomized block design (RBD) with eleven treatments viz., absolute control, recommended dose of fertilizer alone and graded dose of fertilizer along with different sources of vermicompost with foliar nutrition of zinc and boron. Use of different INM practices had significant influence on growth and yield of sunflower hybrid. The effect of integrated nutrient management (INM) practices on growth attributes, yield attributes and yield of crop was critically studied under sunflower hybrid. An effort was also made to study the quality character of sunflower viz., oil content, crude protein and oil yield kg ha^{-1}.The growth and yield components of sunflower hybrid viz., plant height, leaf area index, dry matter production, number of days to fifty per cent flowering and head diameter, number of seeds head^{-1}, percentage of filled seeds head^{-1}and seed yield were strikingly impressive by 75 % RDF along with pressmud vermicompost at 2.5 t ha^{-1} + foliar spray of $ZnSO_4$ @ 0.5 % + Borax @ 0.2 % on 40 and 60 DAS. The same treatment also significantly registered higher values of oil and crude protein content and oil yield kg ha^{-1}.It was followed by 75 % RDF + FYM vermicompost @ 2.5 t ha^{-1} + foliar spray of $ZnSO_4$ @ 0.5 % + Borax at 0.2 % on 40 and 60 DAS.Significantly lowest values for growth attributes, yield attributes and seed yield and quality charactersof sunflower was recorded under control (No fertilizer and no organic manure).

***Keywords: Organic** manures, Vermicompost, Boron, Zinc, Sunflower Growth attributes, Seed yield, Oil content and Oil yield.*

Introduction

Sunflower is a day neutral, short duration, drought and salinity tolerant oil seed crop. Among the different edible oil producing crops, it is one of the most important annual crops in the world. It is one of the fastest growing oilseed crops in India. The oil contains 64% linolic acid, 20-25% oleic acid and 40- 44% protein in cake along with sufficient amount of calcium, iron and vitamins like A, D, E and B complex. At present the annual edible oil requirement of the country is about 18.24 MT of which only 8.04 MT is met by local production and rest of the oil requirement about 10.20 MT is being important. To provide oil seeds to the exploding population, it is obligatory to produce double the present oil seed production of the country. Hence there is an urgent need to augment oilseed production on sustainable basis to meet out the needs of the expanding demand. Amongst many factors responsible for its low productivity, the inadequate and imbalanced nutrition of essential nutrients is the most important. For higher productivity and sustainability, integrated use of organic and inorganic sources of nutrients is very important. Vermicompost is a product of biodegradation of organic materials using various species of

earthworms and microorganisms (Yang *et al.*, 2015). Vermicomposts are rich in all essential plant nutrients, humic acids, and vitamins as well as enzymes and plant growth regulators (Singh *et al.*, 2011). Applications of vermicompost individually or in combination with either other organic fertilizers or mineral fertilizers have been proved effective to improve growth and yield of various crops (Javaad and Panwar, 2013). Although research work on organic wastes with inorganic fertilizer on sunflower crop was in plenty, different vermicompost made from various organic sources in sunflower is almost meager. Generally, farmers do not apply micronutrients to sunflower crop hence the quality production is low therefore, for wide spread adoption and exploitation of high yield potential of the crop. Among the micronutrients, zinc and boron play an important role in seed setting and yield of crops. Zinc is required for the biosynthesis of the plant growth regulator such as indole-3-acetic acid (IAA) and for carbohydrate and nitrogen metabolism which leads to high yield and yield components. Boron can influence photosynthesis and respiration and activate number of enzymatic systems of protein and nucleic acid metabolism in plants (Chowdhury *et al.*, 2010). Keeping these points in view, Field experiment was conducted at the Annamalai University Experimental farm, Department of Agronomy, Annamalai Nagar to study the Effect of organic and chemical fertilizer on seed yield, oil content and protein yield of sunflower.

Materials and Methods

Field experiment was conducted at the experimental farm, department of Agronomy, Annamalai University, Annamalainagarto study the Effect of the organic and chemical fertilizer and micronutrients on seed yield, oil content and protein yield of sunflower. The experimental soil was clay loam in texture with pH 7.9, EC 0.45 dsm^{-1}, organic carbon 0.54, and low N (210.0 Kg ha^{-1}), medium in P (27 Kg ha^{-1}) and high in K (278 Kg ha^{-1}). The experiment was laid out in a randomized black design with eleven treatments and replicated thrice. The treatments were Control - (T_1), 100 % RDF - (T_2), 75 % RDF + FYM vermicompost @ 2.5 t ha^{-1} (T_3), 75 % RDF + Pressmud vermicompost @ 2.5 t ha^{-1} (T_4), 75 % RDF + Sewage sludge vermicompost @ 2.5 t ha^{-1} (T_5), 75 % RDF + Water hyacinth vermicompost @ 2.5 t ha^{-1} (T_6), T_2 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_7), T_3 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_8), T_4+ foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_9),T_5 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS- (T_{10}) and T_6+ foliar spray of $ZnSO_4$ @ 0 .5% + Borax at 0.2% on 40 and 60 DAS – (T_{11}).The Sunflower hybrid Sunbred was chosen for this study.The recommended seed rate for sunflower hybrid @ 4 kg ha^{-1} was adopted. One seeds hole^{-1} was dibbled at a depth of 3 cm with a spacing of 60 cm x 30 cm. Vermicompost was applied to experimental plots as per the treatment schedule. A recommended fertilizer schedule of hybrid sunflower *viz.,* 60 kg N, 90 kg P_2O_5 and 60 kg K_2O ha^{-1} was adopted. Nitrogen, phosphorus, and potassium were applied as per treatment schedule. 50 per cent of recommended N was applied as basal and the remaining 50 per cent was applied at 30 DAS. As per treatment schedule, Zinc (0.5%) and Borax (0.2%) was sprayed at 40 and 60 DAS by using of hand operated knapsack sprayer.Five sample plants from each treatment plot were selected at random and tagged for biometric observations growth attributes *viz.,* Plant height, Leaf area index (LAI), dry matter production, days to fifty per cent flowering and yield attributes *viz.,*head diameter, total number of seeds head^{-1}, number of filled seeds head^{-1}, percentage of filled seeds head^{-1} and seed yield (kg ha^{-1}) and harvest index**.**The sunflower crop was harvested at full physical maturity (indicated by the change of colour of the perianth from green to golden yellow). The

capitula in the net plot was harvested, threshed and sun dried for three days and seed yield was recorded at 14 per cent moisture content and expressed in kg ha^{-1}.

Quality characters

Oil content	The oil content of the seed was estimated using diethyl either as extract ant by Soxhlet extractor and expressed in percentage (A.O.C.S., 1946).
Oil yield	The oil yield was worked out by multiplying the oil content with seed yield and expressed in kg ha^{-1}.
Crude protein yield	Crude protein content of seed was calculated by multiplying the nitrogen percentage of the kernel with factor 6.25 (Humphries, 1956).

The data on observations and characters studied were statistically analysed by adopting the procedure of Gomez and Gomez (1984) and for the results that were significant, the critical differences were calculated at 5 per cent probability level to draw statistical conclusion.

Results and Discussion

Growth Attributes

Integrated application of organic and inorganic fertilizers increased the growth attributes of sunflower. Application of 75 % RDF + Pressmud vermicompostalong with foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_9) recorded significantly higher plant height of 171.81 cm, LAI of 5.58 and DMP of 6203 kg ha^{-1}. This might be due to higher availability of both native and applied nutrients in this treatment along with better source and sink relationship in the crop which has contributed to better dry matter accumulation. A similar view of better performance was reported by Devi Dayal and Agarwal (1998). The constant and optimum availability of the essential micronutrients *viz.,* boron and zinc in this treatment might have enabled the sunflower to utilize the soil available nutrients to a maximum extent, facilitating active synthesis and accumulation of photosynthates which reflected upon enhanced values of dry matter production. The results agree with the findings of Shallendrasingh *et al*. (2012).

Yield attributes

The yield potential of sunflower is determined by yield attributes and the values of yield attributes are in accordance with that of growth parameters. Plot received with 75 % RDF + Pressmud vermicompost along with foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS (T_9) registered higher head diameter size of 21.87 cm, number of 786.34 filled seedshead^{-1}, percentage of 83.53 filled seeds head^{-1}. The aforesaid increased yield attributes and simultaneous enhanced yield due to inorganic fertilizer along with pressmud vermicompost might be due to higher nutrient uptake and increased photosynthetic efficiency as evident from increased LAI values. The constant release of N from organic manure, particularly from pressmud vermicompost supplemented with NPK fertilizers might have satisfied the demand at every phenophase of sunflower crop as opined by Ajethkumar (2003). Besides, stimulatory effect of boron, zinc and sulphur on sunflower plant may be due to its role in enhancing metabolic process and enhancing filling percentage of seeds head^{-1}. These results are in harmony with those obtained by Patil *et al.* (2006). The least values of yield attributes registered under T_1 (No fertilizer and no organic manure).

Seed yield

All the INM practices had significantly influenced on seed yield of sunflower. Plots received with 75 % RDF + Pressmud vermicompost along with foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_9) significantly recorded a higher seed yield of 2241.34 kg ha^{-1} which was 85.51 per cent higher than T_1 (no fertilizer and no organic manure) and 46.35 per cent over 100% RDF (T_2). This might be since pressmud vermicompost offer a balanced nutritional release pattern to plants, providing nutrients such as available N, soluble K, exchangeable Ca, Mg and P that can be taken readily by plants (James Pitchai *et al*., 2009) and greater microbial diversity and activity resulting in higher seed and stalk production. Studies have revealed that boron not only improved the nutrients uptake, it also augmented the conversion, translocation of starch to sink region. Similarly, zinc and sulphur being the prime requisite nutrient for formation of several amino acids might have involved in protein synthesis in higher plants. Hence, the effective translocation and storage of photosynthetic assimilates might have resulted in increased seed and stalk yield of sunflower. The results is in accordance with the reports of and Connor*et al.,* (2006) The least seed yield was registered under T_1 (No fertilizer and no organic manure). Among the treatments, 75 % RDF + Pressmud vermicompost along with foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS (T_9) registered higher values of Harvest index. The constant and synchronized availability of boron, zinc and sulphur, the key plant nutrients involved in process of absorption of nutrients, paving way for efficient and economic utilization of available nutrients to the maximum extent for photosynthetic activity and translocation of photosynthates to sink, which might have increased the values of harvest index (Ahmad *et al*., 2009). The control plot (no fertilizers and no organic manure) recorded the least values of harvest index.

Oil content and Oil yield

Different INM treatments had marked influence on oil content and oil yield of sunflower hybrid. Plots received with 75% RDF + pressmud vermicompost along with foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS (T_9) registered higher oil content of 43.15 per cent and oil yield of 967.05 kg ha^{-1}. This might be due to better availability of macro, micro nutrients especially sulphur and trace elements in pressmud vermicompost (Rathika *et al*., 2008). These results also could be explained according to foliar nutrition of boron and zinc sulphate and its effect by increasing LAI, enhancing photosynthesis activity and higher uptake of nitrogen by seeds which, in turn, resulted in an increase in oil content and oil yield of sunflower. These results are in harmony with those obtained by Asad *et al.* (2003). The least oil content and oil yield was recorded under control (T_1).

Conclusion

From the results of the field trial, it can be concluded that 75 % RDF + Pressmud vermicompost along with foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS significantly recorded maximum seed yield, oil content and oil yield of sunflower crop. It was followed by 75 % RDF + Farm yard manurevermicompost along with foliar spray of $ZnSO_4$ 0.5% + Borax at 0.2% on 40 and 60 DAS in sunflower.

Table 1. - Effect of INM practices on growth and yield attributes of hybrid sunflower

Treatment	Plant height (cm)	LAI	DMP	Days to 50% flowering	Head diameter	Number of filled seeds head^{-1}
T_1	65.89	1.56	1736	68.25	7.25	228.77
T_2	92.61	3.01	3343	65.32	11.79	418.72
T_3	142.39	4.62	5140	60.92	18.12	618.59
T_4	148.35	4.82	5356	59.85	18.88	653.50
T_5	139.66	4.53	5042	61.51	17.77	606.49
T_6	134.20	4.36	4845	62.62	17.08	573.21
T_7	109.55	3.56	3955	63.91	13.94	499.29
T_8	164.46	5.34	5937	56.89	20.93	739.92
T_9	171.81	5.58	6203	55.78	21.87	786.34
T_{10}	161.41	5.24	5827	57.62	20.54	724.20
T_{11}	155.65	5.05	5619	58.67	19.81	694.18
SED	2.58	0.07	96	0.47	0.32	13.39
CD (P=0.05)	5.26	0.15	192	0.94	0.68	26.78

Treatment details

- T_1 – Control, T_2 -100 % RDF, T_3 - 75 % RDF + FYM vermicompost @ 2.5 t ha^{-1} , T_4 - 75 % RDF + Pressmud vermicompost @ 2.5 t ha^{-1} , T_5 - 75 % RDF + Sewage sludge vermicompost @ 2.5 t ha^{-1}, T_6 - 75 % RDF + Water hyacinth vermicompost @ 2.5 t ha^{-1} , T_7 - T_2 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS, T_8 - T_3 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS, T_9 – T_4 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS, T_{10} – T_5 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS, T_{11} – T_6 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS.

Table 2. - Effect of different sources ofINM practices on Seed yield (Kg ha^{-1}), harvest index and quality characters of hybrid sunflower

Treatment	Percentage of filled seeds head^{-1}	Seed yield (Kg ha^{-1})	Harvest index	Oil content (%)	Crude protein content (%)	Oil yield (Kg ha^{-1})
T_1	48.40	624.78	27.77	40.68	12.89	254.17

T_2	70.28	1202.78	29.25	41.39	13.03	497.86
T_3	78.02	1849.19	30.56	42.16	13.38	779.53
T_4	79.24	1926.67	30.72	42.37	13.46	816.42
T_5	77.81	1813.75	30.47	42.10	13.36	763.64
T_6	76.31	1742.90	30.30	41.89	13.29	730.17
T_7	71.45	1422.76	29.84	41.69	13.11	593.08
T_8	82.49	2135.78	31.14	42.93	13.62	916.86
T_9	83.53	2241.34	31.33	43.15	13.69	967.09
T_{10}	81.98	2096.23	31.08	42.83	13.60	897.91
T_{11}	80.87	2021.36	30.90	42.62	13.53	861.41
SED	0.47	26.45	0.06	0.08	0.02	10.8
CD (P=0.05)	0.98	52.76	0.14	0.16	0.05	23.76

Treatment details:- T_1 – Control, T_2 -100 % RDF, T_3 - 75 % RDF + FYM vermicompost @ 2.5 t ha^{-1} , T_4 - 75 % RDF + Pressmud vermicompost @ 2.5 t ha^{-1} , T_5 - 75 % RDF + Sewage sludge vermicompost @ 2.5 t ha^{-1}, T_6 - 75 % RDF + Water hyacinth vermicompost @ 2.5 t ha^{-1} , T_7 - T_2 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS, T_8 - T_3 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS, T_9 – T_4 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS, T_{10} – T_5 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS, T_{11} – T_6 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS.

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DEMOGRAPHIC PROFILE OF DAIRY FARMERS IN DHARMAPURI DISTRICT

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Abstract

Demographic profile of dairy farmers was studied inDharmapuri district. Results revealed that age of majority (53.33 %) of farmers involved in dairy farmingwere more than 50 years old. Maximum number of respondents (72%) was maleand 33.33%of dairy farmers were illiterates. Half of the total respondents (50%) had5-7 members in their family and 58.66% belongs to joint family. Major proportion of respondents (38.66%) possess <2.5 acres of land. Majority of the respondents (36%) were involved in dairying along with agriculture activities and49.33% had more than 20 years of experience in dairy farming.

***Keywords**: Profile, dairy farmers, demography, Dharmapuri, dairy farming experience,*

Introduction

India holds first position among other countries in milk production and shares 23% of global milk production. Dairy is the single largest agricultural commodity contributing to 5%of national economy and provides direct employment to more than 8 crore farmers (Economic survey, 2021-22). Dairy enterprise is an important subsector of agriculture, serves as a source of livelihood to farmers and plays a vital role in socio-economic development of the state and country (Animal husbandry policy note, 2020-2021). One of the major constraints in dairy farming is disease occurrence. Infectious diseases decrease dairy cattle production, cause mortality andcreate economic losses to farmers and to the country (Singh *et al.,* 2014). Information on demographic profile of dairy farmers is a prerequisite to design and implement disease prevention and control programmes suitable for the region.

Materials and methods

The study was conducted in Dharmapuri district. Ex-post Facto research design was adopted (Kerlinger, 1964). Stratified random sampling method was followed. Well-structuredand pretested interview schedule was used to collect data from150 animal owners by personal interview method. Descriptive statistics like frequency and percent analysis was done using SPSS.

Results and discussion

Age

Results of age revealed that majority of the dairy farmers (53.33 %) belong to old age group followed by middle age (36.66%) and young age group (10%). Gopi *et al.,* 2020 also reported similar results that major proportion are old aged followed by middleand young categoryof dairy

farmers. It indicates that maximum number of farmers involved in dairy farming is most experienced and their expertise is more useful to the young farmers to increase their income.

Sex

Maximum respondents were male dairy farmers (72%) compared to female farmers (28%). Similar observations were also reported by Christy and Kothandaraman, 2017 that majority of the respondents were male (73.3%) than female (26.7%) in cuddalore district of tamilnadu.

Education

Educational status of respondents implies that majority of the respondent were illiterate (33.33%) followed by higher secondary education (18%), secondary education (17.33), middle school (16%), primary education (9.33%) and minimum per cent have undergone college/university education (6%). Similar results were reported by Pulla *et al.*, 2021.

Family size

In the present study, majority of the respondents have medium sized family (50%) followed by small size (34%) and large family category (16 %). Similar results were also reported by Singh *et al*., 2021 that majority of respondents belong to medium family size followed by large and small size.

Family type

The results of the present study revealed that maximum (58.66%) respondents belong to joint family and minimum (41.33%) are from nuclear family type. Athilakshmy *et al.*, 2021 expressed similar findings that 59.17% were from joint family and 40.83 % from nuclear type family

Occupation

In the present study, majority of the respondents (36%) were involved in dairying and agriculture activities followed by 28.66% in dairying, agriculture, and others activities. Per cent of respondents in dairying cum other activity is 20.66% and 14.66% were involved in dairying as well as other business. Gopi *et al.*, 2020 reported similar results that majority of respondents had integrated agriculture with dairy.

Land holding

About 38.66% of respondents had marginal land holding followed by landless (26%), small (24%) and large (11.33%) category. The fact that majority of the respondents were marginal farmers is supported by observations made by Ramasubramaniyan*et al*., 2016

Dairy farming experience

Nearly half of the total respondents (49.33%) had high experience of more than 20 years in dairy farming followed by medium (35.33%) and low experienced (15.33%). Similarly, Pulla *et al*., 2021 also reported that 50% of dairy farmers had more than 20 years of experience in dairy farming.

Conclusion

The present study revealed that major proportion of dairy farmers in Dharmapuri district were male, old aged, illiterates, lives in joint family, possessing marginal land with high level of experience in dairy farming practices. These demographic profile details areessential for the policy makers to formulate, plan and implement region-specific disease control strategies, developmental

programmes, trainings and government schemes in order to uplift the socioeconomic status of dairy farmers.

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Figure 1: Distribution of respondents (%) according to age, sex, Education, family sizeand family type

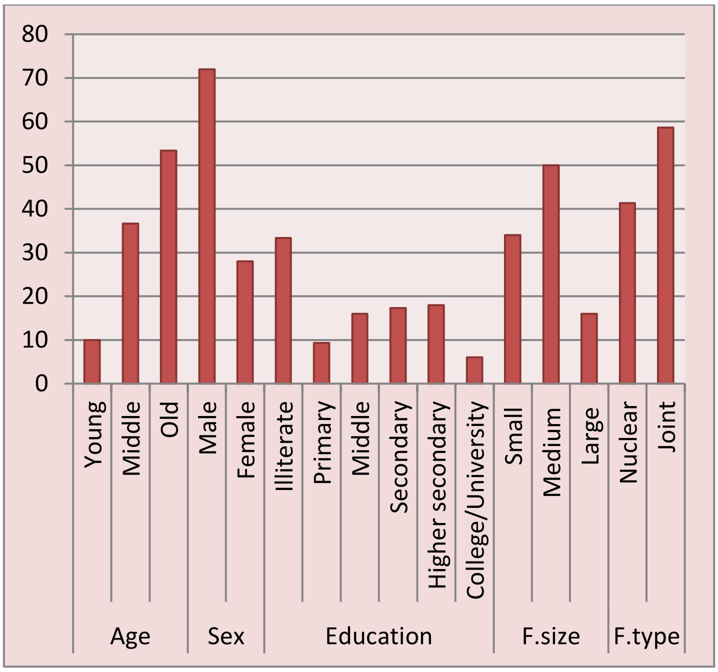

Figure 2: Distribution of respondents (%) according to occupation, land holding and experience in dairy farming

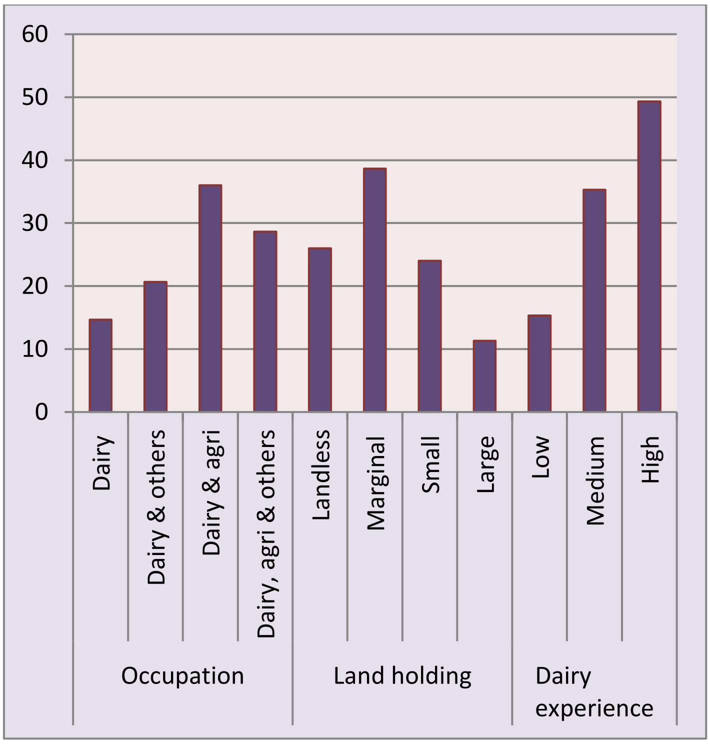

Table 1: Demographic profile of dairy farmers in Dharmapuri (n= 150)

S.No	Variables	Category	Frequency	Percent
1	Age	Young	15	10.00
		Middle	55	36.66
		Old	80	53.33
2	Sex	Male	108	72.00
		Female	42	28.00
3	Educational status	Illiterate	50	33.33
		Primary	14	9.33
		Middle	24	16.00
		Secondary	26	17.33
		Higher secondary	27	18.00
		College/ University	9	6.00
4	Family size	Small	51	34.00
		Medium	75	50.00
		Large	24	16.00
5	Family type	Nuclear	62	41.33
		Joint	88	58.66
6	Occupation	Dairying	22	14.66
		Dairying & others	31	20.66
		Dairying & agriculture	54	36.00
		Dairying, agriculture & others	43	28.66
7	Land holding	Landless	39	26.00
		Marginal	58	38.66
		Small	36	24.00
		Large	17	11.33
8	Dairy farming experience	Low	23	15.33
		Medium	53	35.33
		High	74	49.33

IN VITRO DROUGHT SCREENING IN BLACKGRAM USING POLY ETHYLENE GLYCOL (PEG-6000)

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Abstract

The in vitro screening for drought tolerance was carried out using Polyethylene Glycol (PEG 6000 MW). Drought stress was simulated at four different concentrations namely, -3.0, -5.0, - 7.5 and -10.0 bars of water potential created by dissolving 115, 196, 235 and 289 grams of PEG 6000 respectively in 1000 ml of distilled water. A control (0.0 bars) was maintained using distilled water. At 10 DAS (Days after Sowing) data were recorded on germination percentage, root length, shoot length and root / shoot ratio at four different levels of treatment. Thus, screening of the 20 blackgram genotypes for tolerance to drought at seedling stage using various concentrations of PEG 6000 resulted in the identification of eight genotypes namely, G3, G6, G9, G10, G11, G13 and G19 with drought tolerance.

Keywords: *Blackgram, drought screening, PEG 6000.*

Introduction

Black gram (*Vigna mungo* (L.) Hepper) a self-pollinating diploid (2n=2x=22) grain legume belonging to the papilionoid subfamily of the Fabaceae, is the second important pulse crop of India in terms of area and production next to pigeon pea. Black gram seeds contain about 25% protein and 65% carbohydrates and are a good source of dietary protein and contain higher levels of folate and iron than most other legumes (Keatinge *et al*., 2011). As a legume crop, it fixes atmospheric nitrogen via root rhizobial symbiosis, leading to improved soil fertility and texture (Graham *et al*., 2003). The experiment was carried out through in vitro screening to find out genotypes which are all suitable for drought tolerance using PEG 6000.

Materials and Method

The *in vitro* screening for drought tolerance was carried out using Polyethylene Glycol (PEG 6000 MW) according to Govindaraj *et al.* (2010).

In germination paper, a horizontal line was drawn at 3 cm from the top and was marked with 25 points at 1 cm intervals. Twenty-five seeds of each genotype were placed in the marked point on the moistened paper towel, ensuring that the seeds do not touch each other and a moistened second paper towel was carefully placed over the seeds. The paper towels along with a polythene sheet below it was then rolled loosely to form a tube and held with rubber band. The rolls were placed in the containers of different PEG concentration.

Drought stress was simulated at four different concentrations namely, -3.0, -5.0, - 7.5 and -10.0 bars of water potential created by dissolving 115, 196, 235 and 289 grams of PEG 6000 respectively in 1000 ml of distilled water. A control (0.0 bars) was maintained using distilled water. At 10 DAS (Days after Sowing) data were recorded on germination percentage, root length, shoot length and root / shoot ratio at four different levels of treatment. The experiment was laid in completely randomized design with two replications.

Seedling root length (SRL)

The length between the collar regions to tip of the primary root was measured in ten normal seedlings taken for measuring shoot length and the mean value was recorded and expressed in centimeter.

Seedling shoot length (SSL)

The length between the collar regions to tip of the primary shoot was measured in ten randomly selected normal seedlings and the mean value was recorded and expressed in centimeter.

Root: shoot ratio (RSR)

Ratio of root dry weight (g) to shoot dry weight was calculated.

Germination percentage (GP)

The **germination** test was conducted by adopting between paper methods as described by ISTA (1999). The germination percentage was calculated using the following formula and expressed in percentage.

$$\text{Germination \%} = \frac{\text{No. of germinated seeds}}{\text{Total number of seeds}} \times 100$$

Result

Control

At control, the maximum and minimum value for root length was observed in the genotype G20 (15.94 cm) and G12 (6.79 cm) respectively. Six genotypes recorded significantly superior mean value than the general mean (11.45 cm) (Table 23).

For shoot length, the genotype G20 (28.96 cm) recorded the maximum value and the genotype G12 (13.13 cm) recorded the minimum value respectively. Four genotypes recorded significantly superior mean value than the general mean (13.33 cm). The root:shoot ratio ranged between 0.52 (G5 and G12) and 0.70 (G15) with a mean of 0.59.

The genotypes G1, G2, G6, G15, G16, G17, G35 and G20 (100 per cent) recorded the highest percentage of germination and the genotypes G13 (40 per cent) recorded the lowest percentage of germination. Seven genotypes recorded significantly superior mean value than the general mean (81.00 per cent).

Treatment 1(-3.00 bar)

At -3.00 bars, the maximum and minimum value for root length was recorded by the genotype G6 (4.50 cm) and G2 (16.70 cm) respectively. Eight genotypes recorded significantly superior mean value than the general mean (9.57 cm). Maximum value for shoot length was recorded by the genotype G9 (24.12 cm) and the minimum value was recorded by the genotype G15 (6.00 cm) respectively. Nine genotypes recorded significantly superior mean value than the general mean (14.40 cm). The root:shoot ratio ranged from 0.41 (G11) to 0.98 (G15) with a mean of 0.58. (Table 24)

Highest percentage of germination was recorded by the genotypes G2, G4,G7, G9, G16, G18 and G20 (100.00 per cent) and the lowest percentage of germination was recorded by the genotype G6 (60.00 per cent) respectively. Fourteen genotypes recorded significantly superior mean values than the general mean (74.00 per cent).

Treatment 2(- 5.00 bar)

At -5.00 bars, the maximum and minimum value for root length was observed in the genotype G10 (4.52 cm). Three genotypes recorded significantly superior mean value than the general mean (10.47 cm). The maximum and minimum value for shoot length was observed in the genotype G19 (6.24 cm). Eleven genotypes recorded significantly superior mean value than the general mean (16.35 cm). The root: shoot ratio ranged between 0.51 (G7) and 1.33 (G5) with a mean of 0.69. Two genotypes, G12 and G13, recorded significantly superior mean values than the general mean (0.69). (Table 25)

The genotypes G1, G3, G4, G7, G11, G18 and G20 (100.00 per cent) recorded the highest percentage of germination and the genotype G19 (40.00 per cent) recorded the lowest percentage of germination. Seven genotypes recorded significantly superior mean value than the general mean (80.00 per cent).

Treatment (-7.50 bar)

At -7.5 bars, the genotype G3 (16.30 cm) recorded the maximum value and the genotype G6 (3.52 cm) recorded the minimum value for root length respectively. Eight genotypes recorded significantly superior mean value than the general mean (10.59 cm).

For shoot length, the genotype G19 (17.54 cm) recorded the maximum value and the genotype G6 (6.30 cm) recorded the minimum value respectively. Four genotypes recorded significantly superior mean value than the general mean (12.82 cm). The root:shoot ratio ranged from 0.5 (G) and 1.46 (G3) with a mean of 0.83. Six genotypes recorded significantly superior mean values than the general mean (0.83). (Table 26)

Highest percentage of germination was recorded by the genotypes G9, G10, G11, G13, G15 and G100 (100.00 per cent) and the lowest percentage of germination was recorded by the genotype G6, G8 and G18 (60.00 per cent). Six genotypes recorded significantly superior mean value than the general mean (82.00 per cent).

Treatment 4(- 10.00 bar)

At -10.00 bars, the genotype G13 (15.54 cm) recorded the maximum value and the genotype G1 (4.92 cm) recorded the minimum value for root length respectively. No germination was observed in G10 and G17. Nine genotypes recorded significantly superior mean value than the general mean (10.19 cm). (Table 27)

The genotypes G24, G49 (14.25 cm) recorded the maximum value for shoot length and the genotype G23 (3.30 cm) recorded the minimum value respectively. No germination was observed in G2, G5 and G6. Nine genotypes recorded significantly superior mean value than the general mean (6.92 cm).

The genotype G49 (79.50 per cent) recorded the recorded the highest percentage of germination and the genotype G12 and G13 (22.00 per cent) recorded the lowest percentage of germination respectively. No germination was observed in G2, G5 and G6. Nine genotypes G3, G19, G21, G24, G25, G31, G35, G49 and G50 recorded significantly superior mean value than the general mean (35.32 per cent).

Discussion

The selected 20 blackgram genotypes were screened *in vitro* for evaluating their seedling traits under drought using PEG 6000. The use of PEG for the experimental control of external water potential has been proved to be very effective method for studying the effect of water stress on seed germination and seedling growth characters (Van den Berg and Zeng, 2006). Four different levels of water stress were simulated using various concentrations of PEG 6000 keeping a control.

Reduction in germination percent was observed with increase in stress level. It was observed that reduced germination percentage with decreasing water potential might be caused by low hydraulic conductivity where PEG 6000 makes water unavailable to seeds, thus affecting the imbitional process of the seed which is fundamental for germination (Lobato *et al*. 2009; Mohanlal *et al*., 2021). It has also been reported that PEG-induced osmotic stress can cause hydrolysis of storage compounds that further lower the internal osmotic potentials of the seed (Hampson and Simpson, 1990). Also, this might be due to high viscosity of PEG solution where solubility and diffusion of oxygen were reduced when compared to the control (Radhouane, 2007).

Early and rapid elongation of root is important indication of drought tolerance. A root system with longer root length at deeper layer is useful in extracting water in upland conditions (Kim *et al.,* 2001). In the present investigation, for seedling root length and seedling shoot length also the same trend was observed. Results of this study revealed that severe drought stress can negatively affect germination percentage, followed by shoot and root length. These results corroborate with the findings of Wani *et al.,* (2010). Lawlor (1970) had also observed the retardation in growth of shoot and root length in response to increasing moisture stress under field as well as laboratory condition.

Thus, screening of the 20 blackgram genotypes for tolerance to drought at seedling stage using various concentrations of PEG 6000 resulted in the identification of eight genotypes namely, G3, G6, G9, G10, G11, G13 and G19 with drought tolerance.

Conclusion

Screening of the blackgram genotypes for seedling stage drought tolerance resulted in the identification of eight blackgram genotypes which can be used as potential parents in future breeding programmes.

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Table 23-27: Screening of 20 blackgram genotypes for drought tolerance at seedling stage using PEG 6000

Genotypes	CONTROL				-3.0 BAR				-0.5 BAR				-7.5 BAR				-10.0 BAR			
	RL Mean	SL Mean	RS Ratio	G %	RL Mean	SL Mean	RS Ratio	G %	RL Mean	SL Mean	RS Ratio	G %	RL Mean	SL Mean	RS Ratio	G %	RL Mean	SL Mean	RS Ratio	G %
G 1	13.97**	25.11	0.56	100.00**	0.00	0.00	0.00	0.00	12.02	19.33**	0.62	100.00***	12.32	9.92	1.24**	80.00	4.92	8.80	0.56	60.00
G 2	12.27	20.07	0.61	100.00**	16.70**	20.62**	0.81**	100.00**	11.28	14.78	0.76	80.00	14.10**	12.62	1.12**	80.00	10.98	13.18	0.83**	100.00**
G 3	10.66	17.63	0.60	60.00	12.94**	15.60	0.83**	80.00**	12.76*	22.68**	0.56	100.00**	16.30**	11.18	1.46**	80.00	12.12*	18.86**	0.64*	100.00**
G 4	9.64	17.31	0.56	80.00	14.36**	22.32**	0.64	100.00**	10.16	18.92**	0.54	100.00**	11.24	12.40	0.91*	80.00	9.62	16.10*	0.60	100.00**
G 5	10.32	19.77	0.52	60.00	7.92	12.74	0.62	80.00**	8.82	6.64	1.33	60.00	12.82**	12.06	1.06**	80.00	7.80	17.02**	0.46	80.00
G 6	12.39	21.54*	0.58	100.00**	4.50	6.82	0.66	60.00	12.26	21.04**	0.58	80.00	3.52	6.30	0.56	60.00	12.34*	19.62**	0.63	100.00**
G 7	10.86	18.01	0.60	80.00	14.26**	21.32**	0.67	100.00**	11.56	22.45**	0.51	100.00**	8.70	10.86	0.80	80.00	10.02	16.52**	0.61	100.00**
G 8	10.24	16.91	0.61	80.00	11.10	20.40**	0.54	80.00**	11.90	21.50**	0.55	80.00	6.32	10.80	0.59	60.00	9.72	15.38	0.63	100.00**
G 9	10.31	16.69	0.62	80.00	14.12**	24.12**	0.59	100.00**	11.32	20.78**	0.54	100.00**	10.02	14.14	0.71	100.00**	8.40	13.92	0.60	100.00**

G 10	8.89	15.54	0.57	80.00	10.76	15.76	0.68	80.00**	4.52	8.02	0.56	40.00	11.42	14.50	0.79	100.00**	0.00	0.00	0.00	0.00
G 11	7.68	14.48	0.53	60.00	6.80	16.72*	0.41	80.00**	12.00	20.26**	0.59	100.00**	13.04**	15.00	0.87*	100.00**	14.68**	19.98**	0.73**	100.00**
G 12	6.79	13.13	0.52	80.00	7.28	13.20	0.55	80.00**	10.02	12.22	0.82*	80.00	4.70	8.04	0.58	60.00	14.30**	18.82**	0.76**	100.00**
G 13	9.32	15.14	0.62	40.00	0.00	0.00	0.00	0.00	9.58	11.26	0.85**	60.00	12.49**	16.38**	0.76	100.00**	15.54**	18.74**	0.83**	100.00**
G 14	13.18*	19.32	0.68**	80.00	10.50	14.38	0.73	80.00**	10.08	12.78	0.79	80.00	6.48	11.00	0.59	80.00	7.78	9.18	0.85**	60.00
G 15	14.66**	20.80	0.70**	100.00**	5.86	6.00	0.98**	80.00**	6.36	10.64	0.60	60.00	8.92	14.76	0.60	100.00**	15.10**	17.22**	0.88**	100.00**
G 16	15.59**	23.33**	0.67**	100.00**	14.14**	20.86**	0.68	100.00**	8.88	15.04	0.59	60.00	12.98**	15.54*	0.84	80.00	10.16	14.48	0.70**	80.00
G 17	12.33	19.41	0.64	100.00**	11.46	14.22	0.81**	80.00**	11.92	20.74**	0.57	80.00	12.86**	16.70**	0.77	80.00	0.00	0.00	0.00	0.00
G 18	10.13	18.02	0.56	60.00	14.04**	22.74**	0.62	100.00**	13.86**	21.12**	0.66	100.00**	8.34	13.76	0.61	60.00	14.18**	18.82**	0.75**	100.00**
G 19	13.78**	25.40**	0.54	80.00	0.00	0.00	0.00	0.00	6.28	6.24	1.01	40.00	12.00	17.54**	0.68	80.00	13.94**	19.54**	0.71**	100.00**
G 20	15.94**	28.96**	0.55	100.00**	14.68**	20.24**	0.73	100.00**	13.84**	20.50**	0.68	100.00**	13.26**	12.94	1.02	100.00**	12.18*	15.24	0.00	100.00**
Mean	11.45	19.33	0.59	81.00	9.57	14.40	0.58	74.00	10.47	16.35	0.69	80.00	10.59	12.82	0.83	82.00	10.19	14.57	0.59	84.00
Min	6.79	13.13	0.52	40.00	4.50	6.00	0.41	60.00	4.52	6.24	0.51	40.00	3.52	6.30	0.56	60.00	4.92	8.80	0.46	60.00
Max	15.94	28.96	0.70	100.00	16.70	24.12	0.98	100.00	13.86	22.68	1.33	100.00	16.30	17.54	1.46	100.00	15.54	19.98	0.88	100.00
CD (p=05)	1.08	1.13	0.02	1.30	1.41	1.58	0.10	1.85	1.3	0.94	0.08	1.85	1.24	1.6	0.01	1.86	1.21	0.98	0.02	2.17
CD (p=01)	1.57	2.12	0.06	1.7	1.92	2.1	0,14	2.51	1.72	1.25	0.11	2.45	1.65	2.11	0.07	2.46	1.64	1.27	0.07	2.89
SE	0.45	0.76	0.02	0.65	0.7	0.69	0.09	0.95	0.63	0.45	0.04	0.85	0.56	0.75	0.03	0.90	0.55	0.45	0.03	1.07

KNOWLEDGE LEVEL OF FARMERS ON COMMON PURSLANE (*portulaca oleraceae*) IN TAMIL NADU USINGSIMPLE RANDOM SAMPLING METHOD

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Abstract

The present investigation was carried out in southern state of India. Tamil Nadu is one among the southern states of India comprises of 38 districts which are formed as four sub-regions by objective regionalization with an objective to obtain the knowledge level of farmers about common purslane. Simple random sampling method was used to select a total of 200 respondents. The data were gathered using structured interview and analyzed with appropriate statistics tools. It was discovered that majority of the farmers are elders and had completed elementary schooling. Out of their total landholdings small and medium areas were under cultivation of leafy vegetables. Majority of the respondents in the sample had medium level of knowledge on common pursalne. The study recommends nutritionists and horticulturists to utilize the crop for research and provide reliable information about the crop and standardize the cultivation practices for the crop.

***Keywords**: Common Purslane, Portulaca, TamilNadu.*

Introduction

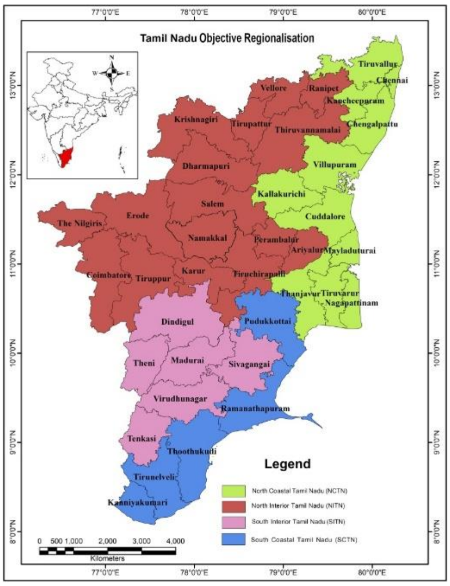
India is a developing country where industrial revolutionis inevitable. The industrial globalization coupled with population explosion causes major issues to people and plant species. Nowadays it becomes common that people suffer non-communicable diseases (NCDs) like cardiovascular diseases (CVD), diabetes, chronic respiratory diseases, and cancer. These diseases are driven by forces that include rapid unplanned urbanization, globalization of unhealthy lifestyle. Recently many traditional medicinal plant species are threatened with extinction through urbanization and the force of industrialization. NCDs have become a major globalburden in both developed and developing nations (WHO, 2012). Dietary supplements are widely used and offer the potential to improve healthy lifestyle (Rautiainen *et al*., 2016). Purslane (*Portulacaoleracea* L.) belongs to the family Portulacaceaeis most commonly identified as a weed but,it is considered to be an important under-utilized green leafy vegetable in human diet.World Health Organization (WHO) has listed itas mostly used medicinal plants, and it has beengiven the term “Global Panacea” (Xu*et al*., 2006).Purslane is a very good source of omega-3 fatty acid; it has been shown to containfive times higher omega-3 fatty acids than spinach (Kamal *et al*., 2013). Levels of triglycerides were substantially lowered by omega-3 fatty acids in some clinical trials (Campbell *et al*., 2013), threetrials reported that omega-3 fatty acids supplementation (1.0–1.8 g) reduced total CVD or coronary events by 8–19% (Gissi,1999; and Tavazzi*et al*., 2008). Type 2 diabetes is accelerated rates of micro- and macrovascular complications, extract of purslane suppresses hyperglycemia and diabetic vascular inflammation, and prevents thedevelopment of diabetic endothelial dysfunction for the development of diabetes and its vascular complications (Lee *et al*., 2011). Purslane is a hidden gem it deserves a special attentionfrom agriculturalists as well as nutritionists (Uddin *et al*., 2010). So growing dietary supplement foods during these centuries is an

utmost importance among the farmers. Therefore, farmers must haveknowledge on purslane. In this regard, a study was conducted in TamilNadu to know the knowledge of farmers about purslane.

Materials and Methods

The current study was conducted in Tamil Nadu, which is one of the southernmost statesof India. The proximity of sea influences the climateof eastern and southern part of Tamil Nadu whereashilly orography and distance from the sea play animportant role over rest of the state. Tamil Nadu is comprised of 38 districts and for the present study it is difficult to collect sample from all the districts. So, for the study purpose based on objective regionalization 38 districts were formed into four sub regions mainly based ontheir proximity to coast and their geographicallocation for the purpose of regional level survey of knowledge level of purslane among Tamil Nadu farmers (Fig.1). They arenamely, (1) North Coastal Tamil Nadu (NCTN), (2)South Coastal Tamil Nadu (SCTN), (3) NorthInterior Tamil Nadu (NITN) and (4) South InteriorTamil Nadu (SITN).It shall be noted that objective regionalization is not a factor for theclassification of districtsfor administrative purposes.Objective regionalization isbased on various climatevariables like temperature and rainfallare thebasis for division of large areas into many sub regions (Asokanand Sivagnanam, 2014).Barring (1987)applied common factor analysis for theregionalization of daily rainfall of Kenya. Also objective regionalization was done by Sumner *et al* (1993) for Mallorea, Periago*et al* (1991) for Catalonia and Romero *et al* (1999) for whole of Spain. Tamil Nadu possesses diverse climatic regions where all sort of vegetables can be cultivated. Among vegetables, green leafy vegetable holds a special place in Indian cuisine due to its medicinal value, high nutritional profile and easy availability. Some greens are recognized as traditional medicines and still in use. But they are suitable for local markets only, due to its perishability and seasonal availability. Under-utilized crops are neither grown commercially nor traded (Bhavithra*et al*., 2019). Purslane is under-utilized or utilized by specific people throughout the world and even diminished in use which leads to the species extinct. It is a cropthat possess nutraceutical properties but not popular among farmers and people. Considering these facts a total of 200 leafy vegetable farmers from Tamil Nadu were chosenusing simple random method (50 respondents from each regions) and collected data through personal interview in an informal way from respondents.

Fig.1. Districts and four sub-regions of Tamil Nadu



Results and Discussion

Table 1. Descriptive characteristics of green leafy vegetable farmer

S.No	Characteristics	Minimum	Maximum	Average
1.	Age	22	65	42.36±12.68
2.	Education	2	12	5.89±2.65
3.	Operational landholding (in acres)	0.4	15	4.53±2.31
4.	Area under leafy vegetables (in acres)	0.4	3	1.05±0.63

Data are mean values with standard deviations

Table 2. Knowledge level of purslane among the farmers

n=200

S.No	Particulars	Yes		No	
		f	%	*f*	%
1.	Identification of Purslane	184	92	16	8
	1a. Weed	122	61	78	39
	1b. Green leafy vegetable	16	8	184	92
	1c. Medicinal crop	10	5	195	95
	1d. Ornamental crop	36	18	164	82
2.	Cultivation of purslane	11	5.5	189	94.5
	2a. (*If yes*) Specific management practices	0	0	200	100
	2b. (*If no*)Presence of purslane as weed in the field	166	83	34	17
3.	Utilization of purslane				
	3a. Vegetable	24	12	176	88
	3b. Medicine	6	3	194	97
	3c. Animal feed	15	7.5	185	92.5
4.	Marketing of purslane	17	8.5	183	91.5
	4a. Local market	7	3.5	193	96.5
	4b. Nearby city	10	5	190	95
	4c. Export	0	0	200	100
5.	Dumping as weed	183	91.5	17	8.5
6.	Cultivation of purslane on growing demand in future	200	100	0	0

f – Frequency; % - Percentage; n – Total respondents.

The descriptive characteristics of leafy vegetable farmers surveyed in the study area are depicted in Table 1. On average, the age of the sampled leafy vegetable farmers was 42.36 years indicating 'elder' people were largely engaged in greens cultivation. Most of the growers were

educated from ‘elementary’ to ‘secondary’ level; few farmers are illiterate and some of the farmers possess ‘master degree’, reflecting that greens cultivation involves all people of the society. Generally, sampled respondents had average landholding of more than 4.00 acres indicating that most of the farmers are small farmers. Further, Table 1 also indicated that respondents did leafy vegetable cultivation in small areas of the total landholdings. This revealed the diversified category of the farmers was engaged in leafy vegetable farming.

From Table 2 the knowledge level of farmers about the common purslane is known. Most of the respondents were full time farmers, 92 per cent of them have knowledge about the crop and 8 per cent of farmers did not know about the crop.The respondents who have identified the crop were asked further about the identity of the crop, majority of the respondent identified purslane as a weed crop 56 per cent, 16 per cent of them identified it as leafy vegetable, 10 per cent of respondent called purslane as medicinal crop and some of them 3 per cent are still using it as traditional medicine, since purslane are also grown for ornamental purpose the question was asked surprisingly 18 per cent of the respondent identified it as ornamental crop which is higher than leafy vegetables and medicinal crop count. During a particular season 5.5 per cent of the farmers of some regions cultivate purslane, and they are lack of package of practice (POP) to grow purslane. There are 3.5 per cent of the farmers who sell the purslane in their local markets and the repondents from NCTN & NITN sell purslane to the nearby cities (5 per cent) which is higher than the local markets that ensures the knowledge of crop among the urban consumers. Apart from the growers 83 per cent of the farmers from various regions had encountered the existence of pursalne, it is a warm-climate, herbaceous succulent annual plant with a cosmopolitan distribution (Yan *et al*., 2015). Among the respondents 12 per cent of the farmers are using the purslane as leafy vegetable including cultivators and non-cultivators. Whereas the excess of purslane from their field are dumped as weed 91.5 per cent and some of them 7.5 per cent feed it for their live-stocks. Although after explaining about the nutritional profile of the crop all respondents understood the potentiality of the crop and showed green signal to raise the crop on demand among the consumers.

Table 3. Over all Knowledge level of Farmers on Purslane (*Portulacaoleraceae*)

n=200

S.No	Overall Knowledge	Frequency	Percentage
1	Low	30	15.00
2	Medium	120	60.00
3	High	50	25.00

The data in table 3 reported that majority 60 per cent of the respondents were found to have a medium level of overall knowledge followed by 25 per cent high level of knowledge and 15 per cent of them possess low level of knowledge on common purslane. These finding derive support from Balaji and manjunath (2011).

Conclusion

The study discovered that the majority of the farmers are ready to grow purslane commercially. According to the leafy vegetable growers there are some challenges to grow greens, so from the study it recommends the horticulturist to conduct several researches on such potential crop to standardize the agronomic practices, cultivation and management aspects.

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ENHANCEMENT OF SEED YIELD AND SEED QUALITY IN BLACKGRAM THROUGH SEED HARDENING

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Abstract

Pre-sowing hardening is one of the best methods that results in modifying the physiological and biochemical nature of seed so as to get the characters that are favourable for drought resistance. The current study was carried out to elucidate the effect of pre-sowing seed hardening treatment on crop growth, seed yield and seed quality in blackgram. The seeds of blackgram T9 were hardened with different agents viz., 1% $ZnSO_4$, 1% $MnSO_4$, 1% $CaCl_2$, 1% KCl, 1% KNO_3 5% cow dung + 5% Cow urine, 10% Cow dung, 10% Cow urine and 5% Cow dung + 5% Goat dung along with control. All the treated and untreated seeds were evaluated for seed yield contributing characters and seed quality under field condition and laboratory condition. From the field evaluation, it was observed that 1% $ZnSO_4$ hardening treated seeds recorded higher values for the growth and yield attributing characters. The resultant seed of 1% $ZnSO_4$ hardened plant registered significantly higher values of quality parameters when compared to other treatments and control. From the study, it was found that seeds hardened with 1% $ZnSO_4$ performed better than all other treatments in seed yield and seed quality.

Keywords: Hardening, Blackgram, Zinc sulphate, Calcium chloride, Yield traits.

Introduction

Blackgram is highly prized pulse among all the pulses. Blackgram (*Vigna mungo* (L.) Hepper), is mainly cultivated in Indian subcontinent. Blackgram prefers loamy soil and suitable for intercropping with different crops such as cotton, sorghum, pearl millet, greengram, maize, soybean, groundnut, for increasing production and preserving soil fertility. The reason for low productivity was since pulses are grown mostly under marginal and rainfall areas. The main constraints in raising the productivity levels of pulses in dry lands are the inadequate soil moisture, poor fertility status of the soil, lack of quality seed, poor keeping quality and lack of storage facilities. Seed quality is the major decisive factor governing stand establishment of any crop. Several diverse materials at varying doses have been used to increase the rate and uniformity of seedling emergence in pulses under unfavourable condition.

Drought is very important factor, which affects the Indian cultivator. The water balance of a plant is upset by drought and because of this, the physiological function responsible for growth and yield are disarranged. Seed hardening may be defined as post-harvest treatments that improve germination and seedling growth to facilitate the delivery of seeds and other inputs/materials required at the time of sowing smoothly. With the above background, the current experiment was conducted to assess the effect of pre-sowing seed treatment on seed yield and seed quality in blackgram.

Materials and Methods

Genetically and physically pure seeds of blackgram T9 were given hardening treatment with the following chemicals and organics *viz.*, T_0 – Control, T_1 – 5% Cow dung + 5% Cow urine, T_2 – 1% $ZnsO_4$, T_3 – 1% $MnSO_4$, T_4 – 1% $CaCl_2$, T_5 – 1% KCl, T_6 – 1% KNO_3, T_7 – 10% Cow dung,

T_8 – 10% Cow urine, T_9 – 5% Cow dung + 5% Goat dung. During pre-sowing seed treatment, seeds were soaked in the respective chemical solutions and organics for 12 hours at the ratio of 1:1 of the seeds. After soaking, seeds were dried back to the original moisture content.

The field experiment was conducted with the above treatment by adopting RBD with three replications. Observation on growth and yield parameters were recorded for each treatment replication wise. The recommended package of practices was adopted for raising the crop. The data collected were subjected to statistical analysis as described by Panse and Sukhatme (1985).

Results and Discussion

Seed hardening technique has come a long way since Henkel's time and modified to suit various needs as determined by environment. Pre-sowing hardening is the result of extensive physiological reorganization induced by dehydration process (Sujatha *et al.,* 2013). Higher germination percentage (91%) and speed of germination (12.66) was recorded by T_2 showed the benefits of hardening which may be due to number of physico-chemical changes occur that modify the protoplasmic characters, increasing the embryo physiological activity and associated structures (Ganesh *et al.,* 2013). Subsequent improvement in germination and speed of germination T_2 of the hardened seed could be since such advanced seed would retain viability to carry on where they left off upon germination. Increment might be possible due to an exhaustive utilization of amylase enzyme activity during the early and enhanced rate of germination in hardened seeds as compared to control (Farooq *et al.,* 2010).

Higher seedling length including root and shoot length was recorded by T_2. Seed hardened with T_2 significantly increased root length (18.96 cm) and shoot length (24.26 cm) among the treatment including control. Seedling length traits such as root length showed an increment of 20.99% and shoot length by 18.86% increment over the untreated control seeds (Fig. 1). The improvement in seedling length (both root length and shoot length) may also be due to the enhanced metabolic activity and enzyme activity which hydrolysis the stored reserved food material and make available high energy bio-molecules and vital components to growing points and the presence of growth promoting substance GA_3, auxin, IAA which induces elongation of cells thereby increasing root and shoot length (Ganesh *et al.,* 2013).

The maximum dry matter production was observed in treatment T_2 (0.296 g/10 seedlings) while the control registered minimum dry matter production (0.220 g/10 seedlings) (Fig. 1). The increased dry matter production over the control may be due to simultaneous effect of repair mechanism induced by hardening and synchronized earlier germination that makes seedling entry into the autotrophic state well in advance to produce more photo assimilate from source to sink there by increase the dry matter production.

Higher seedling vigour index I (3948) and II (27) was recorded by T_2 over control (3139 and 19 respectively) (Fig. 1). Higher seedling vigour index was recorded by T_2 over control was due to the increased germination percentage, root length, shoot length and dry matter production of seedlings. $ZnSO_4$ treatment seeds showed the increased seedling quality, which may be due to the beneficial effects of $ZnSO_4$ in strengthening the cell membrane integrity and permeability.

Hence, from the present study, it was revealed that 1% $ZnSO_4$ hardening treatment improves the seedling quality in compared to control due to the cumulative effect of hardening and $ZnSO_4$ on seedling character.

In field study (growth parameters), when compared to other treatments, (T_2) 1% $ZnSO_4$ recorded significantly higher values for al the characters studied namely, days to first flowering, days to 50 per cent flowering, number of nodules per plant, plant height (cm) and number of branches per plant. The improvement in vegetative growth parameters (days to first flowering, days to 50% flowering, number of nodules per plant, plant height and number of branches per plant) might be due to the cumulative effect of hardening and $ZnSO_4$ that could have triggered the biosynthesis of nucleic acids and proteins. The consequential enhancement of cell division and cell enlargement by zinc besides the enhanced metabolic activity of the plant resulting in the increased uptake of nutrients which are associated with improved crop growth (Iqbal *et al.,* 2012 and Pawar *et al.,* 2003). In case of the untreated seeds T_0, the plant registered the reduced plant height. The mechanism of reduction in plant height may be due to the reduced cell size, cell thickening, reduced the rate of enzyme activity and poor availability of nutrient to the growing seedlings which favours delayed emergence and reduced vigour.

In field study when compared to other treatments, (T_2) 1% $ZnSO_4$ recorded significantly higher values for all the characters studied namely, number of nodules per plant (19.67), number of clusters per plant (11.67), number of pods per plant (25), pod length (5.49 cm), pod yield per plant (7.73 g), number of seeds per pod (6.0), hundred seed weight (4.09g) and seed yield per plant (5.27 g) (Fig. 2). This might be due improved mobilization of nutrient. $ZnSO_4$ also plays a major role during the early stage of *Rhizobium*-Legume symbiosis (Ramussen *et al.,* 1991).

The probable reasons for improvement in yield attributes number of clusters per plant, number of pods per plant, number of seeds per pod and hundred seed weight might be due to the hardening chemicals which accelerate the synthesis of protein and nucleic acid, bound water content, repair mechanism and growth of seedling resulting in increasing uptake of nutrients and ability of treated plants to unfavourable condition when compared to control (Pradhan *et al.,* 2018).

Improvement in total dry matter might be due to the increased mobilization of nutrient towards the pod development which resulted in lower number of seeds per pod and increase in normal seed might be due uniform distribution of photo assimilates within the seeds. The improved weight (100 seed weight) from the T_2 hardened seeds might be results of improved photo assimilation and its translocation and partitioning from sources towards the sinks (Parameswari *et al.,* 2021). Similar results were reported by Rehman *et al.* (2011); Sujatha *et al.* (2013) and Patil *et al.* (2014).

In contrast, the control registered the minimum values for yield attributing characters including number of pods per plant, pod yield per plant, number of seeds per pod and 100 seed eight might be due to the slow starch hydrolysis due to the poor availability of water and curtailed emergence of seedling seems to be relative to in efficient mobilizaion and utilization of seed resources. From the present study, it was evident that the control plants have a poor plant establishment, poor vegetative growth which results in lesser photosynthesis and reduced translocation of photo assimilate from sources to sink.

In laboratory condition, resultant seed of 1% $ZnSO_4$ (T_2) recorded significantly higher values for all the seed quality studied namely germination percentage (93%), speed of germination (12.87), root length (19.03 cm), shoot length (24.53 cm), seedling length (43.57 cm), dry matter production (0.36 g/10 seedling), vigour index I (4037) and vigour index II (33) (Fig. 3). The improved seed quality of resultant seeds might also due to the more food reserved materials in

seeds and reduced stress condition during seed maturation and development favoured this positive effect. It might also be due to the enhanced crop stands, growth and yield that ultimately results in the improvement of seed quality (Patil *et al.,* 2014; Amin *et al.,* 2016).

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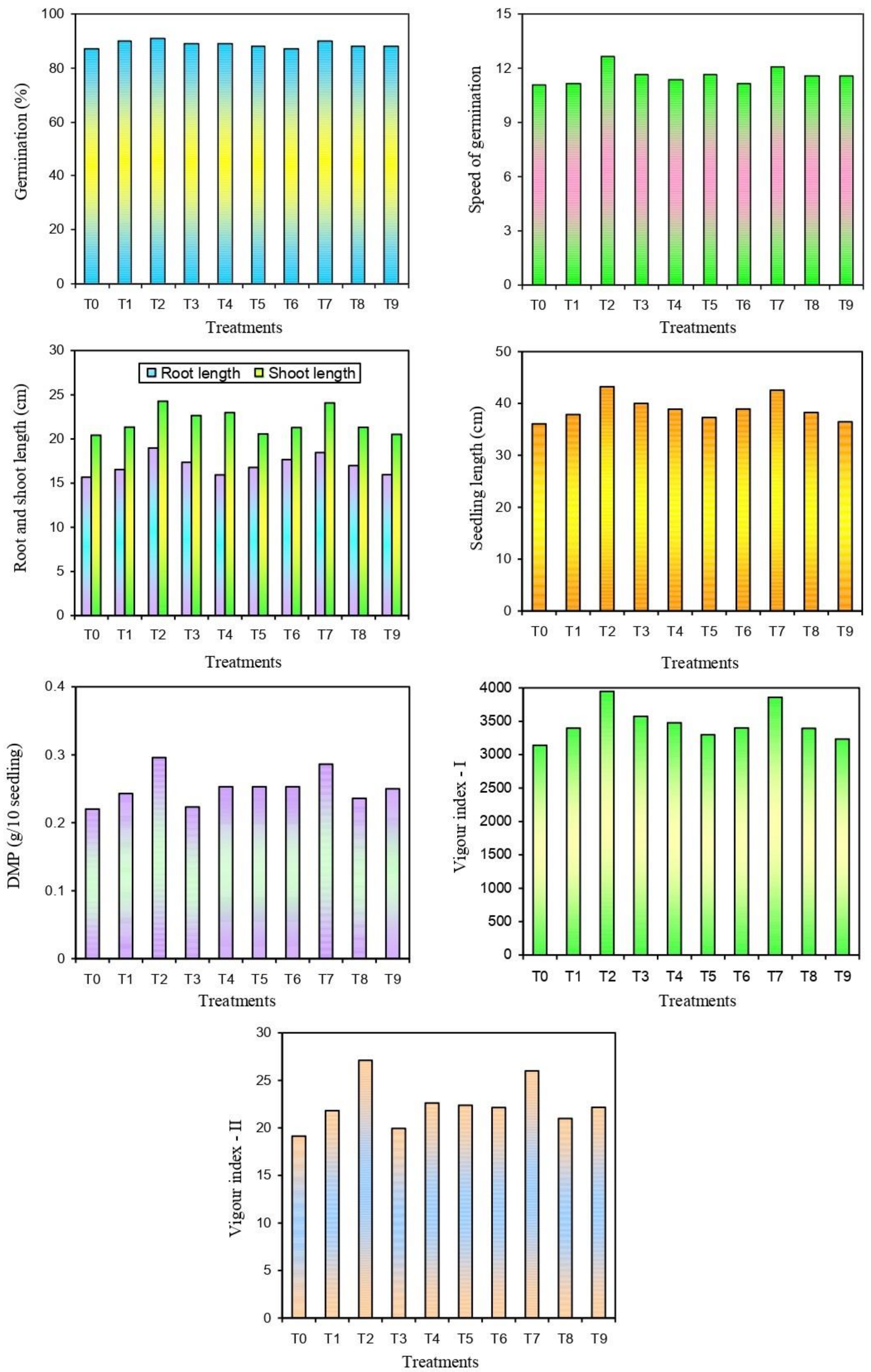

Fig. 1. Effect of seed hardening treatment on initial seed quality parameters in blackgram cv. T9

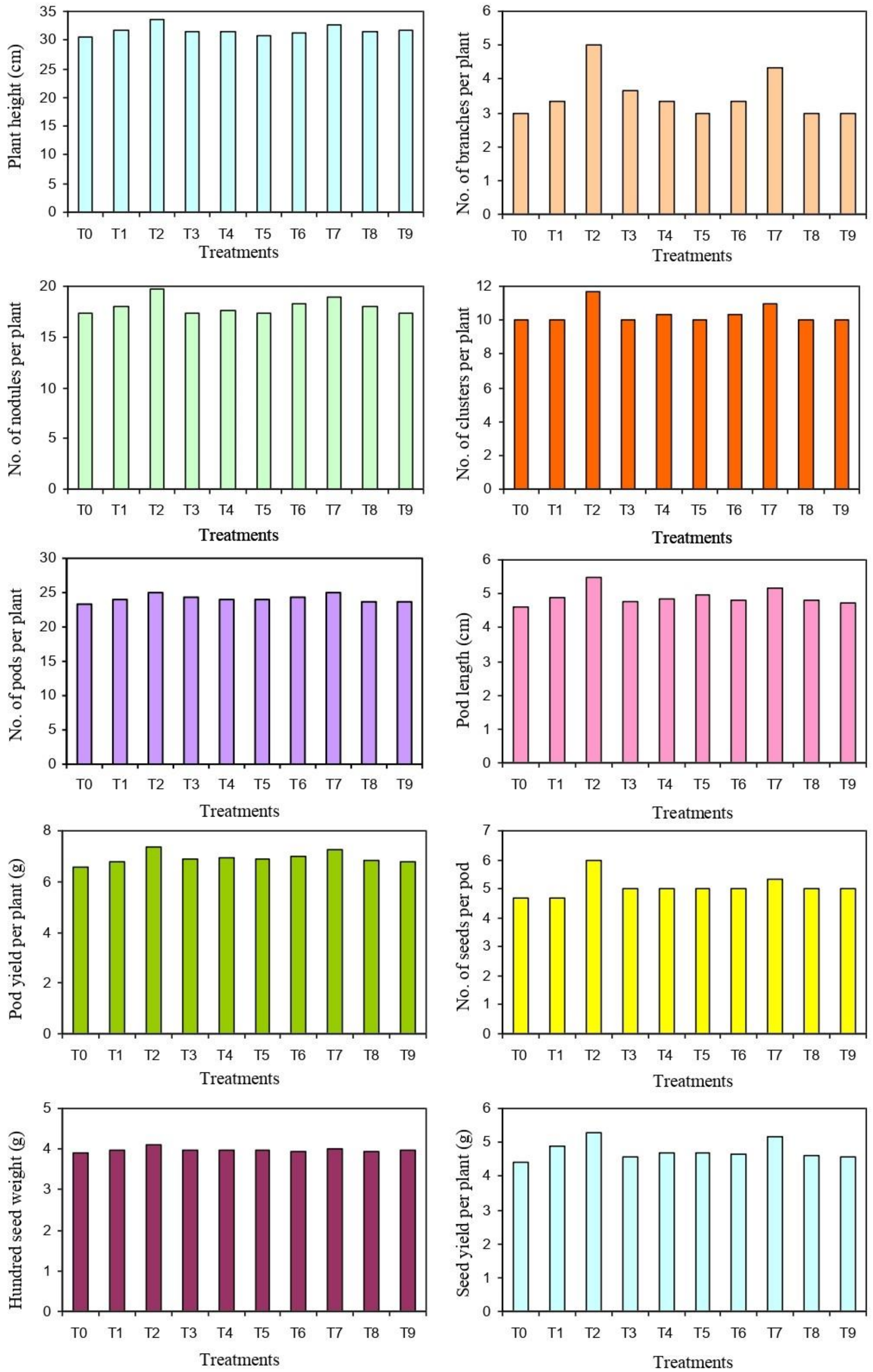

Fig. 2. Effect of seed hardening treatment on growth and yield parameters in blackgram cv. T9

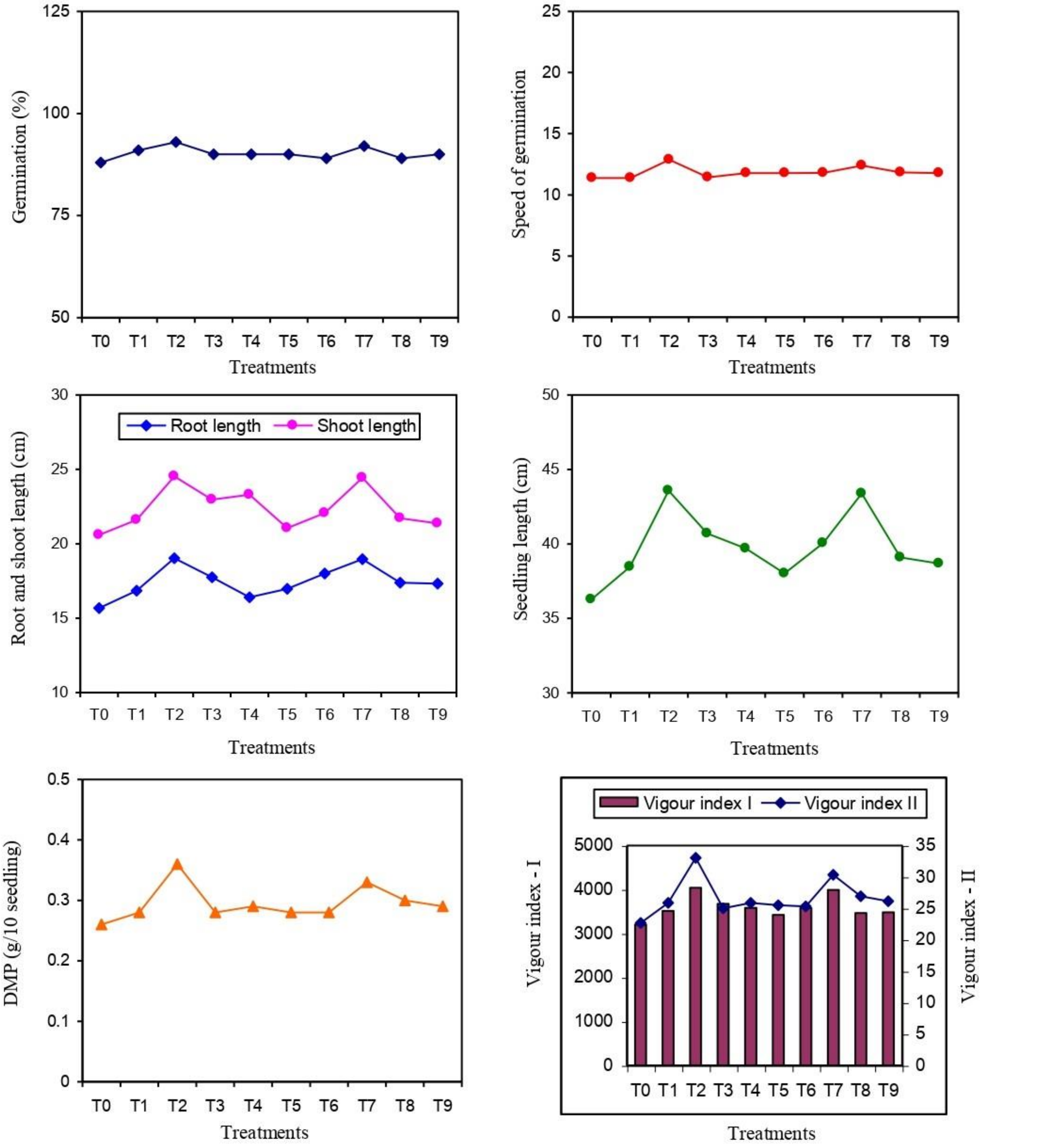

Fig. 3. Effect of seed hardening treatment on initial seed quality parameters in blackgram cv. T9

STABILITY ANALYSIS IN FINGER MILLET [*Eleusine coracana* (L.) GAERTN] GENOTYPES USING LEWIS STABILITY FACTOR MODEL

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Abstract

The present study was carried out to stability analysis and to identify the stable high yielding finger millets genotypes for further utilization. Twenty-one finger millet genotypes and eleven quantitative traits were tested over three locations in Tamil Nadu viz., Dharmapuri (Koothappadi), Krishnagiri (Natrampalayam), Cuddalore (Genetics and Plant Breeding Farm, Annamalai University, Annamalai Nagar). Among twenty-one genotypes studied, four genotypes viz., G3 (Co (Ra) 13), G17 (Vensurutai), G20 (Karunsuruttai) and G21 (Trichy-3) were deemed as stable genotypes. Environmental indices revealed Dharmapuri as ideal test location for finger millet cultivation.

Key words: *Finger illet, genotype x environment interaction, stability, stability factor*

Intoduction

Finger millet (*Eleusine coracana* (L.) is one of the most pre-eminent sustenance millets, widely cultivated in the arid and semi arid regions of Africa and south Asia. It is the stable food of tribal and rural working people. This is a rich source of calcium, iron, protein, fiber and other minerals. Genotype and environment interaction is an important and essential component of plant breeding programme dedicated to variety development. Genotypic stability is an important aspect of the analysis of GXE-interaction. Its importance to plant breeders is immense. The performance of each genotype is assessed for its adoptability to the environment in which it was tested or to other environments, if they are selected at random. The genotype should regain the state of several years and at the same time continue to be superior in its performance. Genotype show wide fluctuation in their yield ability when grown in different environments. The capacity of a crop to perform well over a range of environmental conditions, Stability in productivity, therefore, is a major and important consideration for the plant breeder. The present study was undertaken to identify high yielding and stable finger millet genotypes. The main objectives were to estimate G x E interaction for grain yield and its components for specific agro –climatic situations.

Materials and Methods

The present investigation “Stability analysis in finger millet (*Eleusine coracana* (L.) Gaertn) genotypes” was undertaken during 2018-2019. Stability analysis was carried out at three locations namely, Dharmapuri (Koothappadi), Krishnagiri (Natrampalayam), Cuddalore (Genetics and Plant Breeding Farm, Annamalai University, Annamalai Nagar). The twenty-one genotypes of finger millet were sow in Randomized Block Design (RBD) with three replications at each location. The seedlings were raised in the raised nursery bed method. Twenty days old seedlings were transplanted in three-meter rows with a spacing of 30 cm between rows and 10 cm between two hills in a row. The agronomic practices were applied equally according to local agro-ecological conditions. Analysis of variance and the corresponding standard errors of the mean were computed

from the deviation of the individual values Panse and Sukhatme (1967). The stability factor was estimated using the formula suggested by Lewis (1954). Stability factor unity indicated the maximum phenotypic stability and stability factor greater than unity, indicated less stable for the genotype over the environment. Stability analysis was carried out using the Eberhart and Russell (1966) model. The analysis of variance and stability analysis were done using computer software TNAUSTAT.

Results and Discussion

The analysis of variance for various environments and linear components of all the eleven characters are given in Table 1. Variance due to genotypes was highly significant for all the eleven characters in all the three environments and for pooled data over environments. The variance due to the environment and genotype x environment (G x E) for pooled over locations were highly significant for all the traits studied. The linear component of genotype and environment (G x E) interaction was significant for all the characters. The non-linear component (pooled deviation) was significant for all the characters. Significant mean square for genotype x environment (G x E) were observed for all the traits indicating that the genotypes were considerably influenced by the environmental variations encountered across the three locations. Similar results were reported by patil *et al.* (2007), chavan *et al.* (2018), in finger millet. The relative ranking of three environments revealed that Environment 1 was best for all traits except finger length (-8.94 harvest index (-1.16), Environment II was best for all characters except finger length (-7.22) and harvest index (-0.82). Seasonal indices of nine characters were negative in environment 3 (Table 2).

The criterion for identifying a genotype with less fluctuation due to environment for various characters is identified by measuring the ratio between the high mean in any environment and the low mean in any environment. This is the simple measure of the phenotypic stability of a genotype. The stability factor nearing a ratio 1.00 indicated the maximum phenotypic stability. The stability factor (S.F) analysis by Lewis (1954) is employed for corroborating the results on stability performance of genotypes. The genotype G10 (Valathar Ragi) with poor adaptability according to regression model showed more than unity stability factor for all the ten traits. The genotypes G2, G7, G19, G20 and G21 showed around unity stability factor for four yield attributing characters *viz.*, number of productive tillers per plant, number of fingers per ear head, ear head weight and harvest index. The genotypes viz., G3 (Co (Ra) 13), G17 (Vensurutai), G20 (Karunsuruttai) and G21 (Trichy-3) showed around unity stability factor for grain yield per plant by this analysis, G20 (Karunsuruttai) local land race can be selected for ideal stable genotype (Table 3).

Conclusion

Thus, the study revealed that the location Dharmapuri was ideal for finger millet cultivation Stability factor indicated four genotypes *viz*., G3 (Co (Ra) 13), G17 (Vensurutai), G20 (Karunsuruttai) and G21 (Trichy-3) as phenotypically stable hybrids across environments. These genotypes are phenotypically stable and further commercially recommended for Dharmapuri and Krishagiri regions, stability parameters are to be considered.

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Table 1: Analysis of variance for stability parameters pooled over three environments in finger millet

*** and ** indicated significant at 5% and 1% respectively**

Df – Degress of freedom, DT50%- Days to 50% flowering, DTM- Days to maturity. PH- Plant height, NPTPP- Number of productive tillers per plant, EHL- Ear head length, EHW- Ear head weight, NFPEH- Number of fingers per ear head, FL- Finger length, HI- Harvest index, GYPP- Grain yield per plant.

S. No.	Characters	E1	E2	E3
1	Days to 50% flowering	7.20	5.91	-13.11
2	Days to maturity	8.05	8.00	-16.05
3	Plant height	12.80	20.31	-33.11
4	Number of productive tillers per plant	0.03	0.20	-0.24
5	Ear head length	1.55	0.33	-1.89
6	Ear head weight	2.41	4.68	-7.09
7	Number of fingers per ear head	0.56	1.13	-1.70
8	Finger length	-8.94	-7.22	1.72
9	Harvest index	-1.16	-0.82	1.99
10	Grain yield per plant	2.39	3.03	-5.43

E1- Environment 1, E2- Environment 2, E3- Environment 3

Table 2: Environmental indices for ten characters

Genotypes	Days to 50% flowering	Days to maturity	Plant height	Number of productive tillers per plant	Ear head length	Ear head weight	Number of finger per ear head	Finger length	Harvest index	Grain yield per plant
G1	1.29	1.22	2.54	1.09	1.14	1.49	2.21	4.25	1.35	2.20
G2	1.45	1.37	2.06	0.92	1.57	1.88	1.59	5.38	1.81	2.39
G3	1.80	1.40	2.08	0.83	1.60	2.32	1.47	4.17	1.06	0.96
G4	1.67	1.48	2.14	2.10	2.25	1.95	1.64	2.58	1.19	2.58
G5	1.31	1.11	2.14	1.21	1.16	1.83	1.86	4.67	0.79	2.13
G6	1.26	1.33	2.03	1.20	2.12	2.31	1.35	2.85	1.33	3.33
G7	1.21	1.26	2.29	0.92	2.01	1.59	2.12	3.82	0.99	2.22
G8	1.26	1.22	1.97	2.11	1.39	1.72	1.13	3.29	1.53	2.70

G9	1.37	1.32	2.98	1.11	1.96	1.81	2.11	2.68	0.89	3.13
G10	1.31	1.16	2.70	1.22	2.00	1.71	1.79	4.12	1.91	3.21
G11	1.18	1.17	1.76	0.89	1.20	1.78	1.57	3.85	1.72	2.34
G12	1.43	1.32	2.87	1.16	1.91	2.01	3.48	3.59	1.57	2.41
G13	1.38	1.22	2.74	1.38	1.44	1.99	1.47	2.92	0.92	2.14
G14	1.37	1.27	2.57	0.88	1.37	1.28	1.19	3.99	0.80	2.51
G15	1.32	1.22	1.88	1.43	1.18	2.37	2.42	3.72	0.92	3.42
G16	1.23	1.20	2.15	0.92	1.70	2.55	1.63	3.21	1.18	2.44
G17	1.29	1.14	1.12	0.98	1.45	0.76	1.08	1.87	0.84	1.10
G18	1.28	1.33	2.17	1.52	1.37	1.74	1.51	3.71	1.18	3.04
G19	1.48	1.33	1.36	0.68	1.27	1.62	1.55	2.89	0.79	3.26
G20	1.55	1.33	1.86	0.95	1.37	0.89	1.03	3.75	1.21	1.02
G21	1.35	1.30	1.51	1.22	1.47	1.36	1.17	2.81	0.88	1.07

Table 3: Lewis stability factor for various characters in twenty one finger millet genotypes

Sources	Df	DT50 %	DTM	PH	NPTPP	EHL	EHW	NFPEH	FL	HI	GYPP
Genotypes	20	27.89**	44.29**	41.04**	0.80**	1.44**	0.24**	1.31**	4.91**	47.07**	15.99**
Environment	2	2718.40**	4061.44**	17568.68**	1.08**	64.50**	43.88**	47.32**	1418.09**	63.17**	466.87**
G×E	40	22.73**	29.70**	86.94**	0.87**	1.89**	0.25**	0.93**	8.90**	31.37**	9.03**
Environment + G×E	42	151.10**	221.69**	919.40**	0.88**	4.87**	2.33**	3.14**	76.01**	32.89**	30.83**
Environment (Linear)	1	5436.81**	8122.89**	35317.36**	2.16**	129.01**	87.76**	94.64**	2836.19**	126.35**	933.74**
G×E (Linear)	20	21.77**	16.63**	108.43**	0.69**	1.48**	0.30**	1.05**	5.07**	35.43**	6.27**
Pooled Deviation	21	22.57**	40.73**	62.33**	1.00**	2.19**	0.19**	0.78**	12.13**	26.01**	11.23**
Error	120	2.37	2.74	43.97	0.16	0.66	0.20	0.30	1.45	8.00	1.40

STUDIES ON EFFECT OF PINCHING AND INTEGRATED NUTRIENTS ON CERTAIN GROWTH AND FLOWERING CHARACTERS OF CHRYSANTHEMUM (*Dendranthema grandiflora*) var. Poornima White

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Abstract

An experiment was carried out to study the Influence of pinching and integrated nutrients on certain growth and flowering characters of Chrysanthemum var. Poornima White in Vellarivelli, Edappadi Taluk, Salem District. The design of the experiment was Randomized Block Design with three replications comprising thirteen treatments. The experiment was conducted by adopting pinching at 30 and 60 days after transplanting using various nutrients viz., Vermicompost @ 1.5 t ha^{-1} and 3 t ha^{-1}, Coirpith compost @ 10 t ha^{-1} and 15 t ha^{-1} along with foliar application of Micronutrient mixture @ 0.5 per cent at 45 days after planting and then with soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP and foliar application of Jeevamrutham @ 5 per cent at 90 and 120 days after planting. Among all the treatments the maximum growth parameters viz.,Plant height (15.75 cm and 56.11 cm at 30 and 90 DAP), Number of branches (4.93 and 28.15 at 30 and 90 DAP), Number of leaves (32.27, 135.00 at 30 and 90 DAP), Plant spread (40.52 cm in North-South direction and 39.75 cm in East-West direction) and Leaf area (33.54 cm^2) and maximum flowering parameters viz.,days taken for first flower bud appearance (56.11 days), number of petals flower^{-1}(186.24), duration of flowering (158.31 days), flower diameter (6.12 cm) and single flower weight (4.87 g) were recorded in treatment T_{11} with the application of 75 per cent RDF along with Coirpith compost @ 10 t ha^{-1} with this pinching is carried out at 30 and 60 days after planting along with foliar application of micronutrient mixture @ 0.5 per cent at 45 DAP and soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP and then with foliar spray of Jeevamrutham @ 5 per cent at 90 and 120 DAP maximized the growth and flower attributing characters. Hence, this treatment combination was found to be the best in increasing the growth and flowering of Chrysanthemum.

Keywords: Chrysanthemum, Coirpith compost, Micronutrient mixture, Jeevamrutham

Introduction

Chrysanthemum, the golden flower is derived from two Greek words (Chryos-golden and anthus-flower), is one of the most beautiful and perhaps the oldest flowering plants commercially grown in different parts of the world. Chrysanthemum (*Dendranthema grandiflora)* chromosome no: 2n = 36 belongs to the family Asteraceae originated from northern hemisphere chiefly Europe and Asia substitutes all commercial loose flowers of a nosegay by its attractive shape and color, this made Chrysanthemum gain greater importance in floriculture industry. The National flower of Japan is Chrysanthemum. Chrysanthemum was introduced to Japan in 8th century A.D. Japan celebrates National Chrysanthemum Day as “The Festival of Happiness” for Chrysanthemum flower. The Japanese emperors loved these flowers and adorned their thrones with these flowers. Chrysanthemum is popularly referred as Guldaudi, Queen of East, and Autumn Queen. Chrysanthemum is partly woody erect perennial herb or sub shrub growing up to 1m in height with

alternate thick leaves. The inflorescence consists of many flower heads. Each flower head has numerous florets namely disc florets and ray florets, but the disc florets only can reproduce. Florets in the centre of the flower is called disc florets which possess stamens and pistil. Chrysanthemum is classified as short - day plant and cannot normally form flower buds when the day length exceeds 14.5 hours. Photoperiodic control of the growth and flowering of Chrysanthemum makes it possible to cultivate this crop all year round. It is commercially grown for cut flowers as well as loose flowers. In India, it is popular as loose flower mainly grown commercially by farmers for making garlands, general decoration, and hair adornments and in religious offerings.

The use of balanced nutrients by avoiding more number of chemical fertilizers is known to improve physico-chemical and biological properties of soil, besides improving the efficiency of applied fertilizers. In order to maximize the yield, Pinching otherwise known as tipping is usually practiced and it is a pruning method generally used on young plants to encourage branching, regulating the flowering time and quality flower production (Jena *et al.*, 2021). Application of organic amendments like Vermicompost and Coir pith compost as a organic nutrients improves the soil texture, soil porosity, and water retention capacity and maintains a congenial microbial population in which it increases the soil nutrition. Application of micronutrient mixture might basically enhanced photosynthetic and other metabolic activities related to cell division and elongation.Jeevamrutham is a liquid organic manure and considered to be an excellent source of natural carbon, biomass, nitrogen, phosphorous and potassium and other micronutrients required for the crop.The present study entitled "Influence of Pinching and Integrated nutrients on growth, flowering, yield and quality of Chrysanthemum var. Poornima White" was taken up with a view to elicit and elucidate the information on the above side facts with the following specific objective to study the combination effect of pinching and integrated nutrients on certain growth and flowering of Chrysanthemum.

Materials and Methods

The present investigation was under taken to study the influence of pinching and integrated nutrients on growth and flowering of Chrysanthemum var. Poornima White in Vellarivelli, Edappadi Taluk, Salem District. The experiment was laid out in Randomized Block Design (RBD) with 13 treatments and replicated three times. The soil type of the experimental field of was sandy clay loam with pH of7.1.The experiment was conducted by adopting pinching at 30 and 60 days after transplanting using various nutrients *viz.,* Vermicompost @ 1.5 t ha^{-1} and 3 t ha^{-1}, Coirpith compost @ 10 t ha^{-1} and 15 t ha^{-1} along with foliar application of Micronutrient mixture @ 0.5 per cent at 45 days after planting and then with soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP and foliar application of Jeevamrutham @ 5 per cent at 90 and 120 days after planting. The observations are recorded on the selected five plants for a treatment in each replication. The plots were kept free from weeds by periodic hand weeding. Pests and diseases were controlled periodically during the entire crop period. The data were subjected to statistical analysis as suggested by Panse and Sukhatme (1985). Data of three replications were tabulated and recorded. The treatment details are shown in the Table 1.

Table 1: Treatment details

T_1	75 % RDF + Vermicompost @ 1.5 t ha^{-1} + Pinching at 30 DAT
T_2	50 % RDF + Vermicompost @ 3 t ha^{-1} + Pinching at 30 DAT
T_3	75 % RDF + Coirpith compost @ 10 t ha^{-1} + Pinching at 30 DAT
T_4	50 % RDF + Coirpith compost @ 15 t ha^{-1} + Pinching at 30 DAT
T_5	75 % RDF + Vermicompost @ 1.5 t ha^{-1} + Pinching at 30 and 60 DAT + Micronutrient mixture @ 0.5 % at 45 DAP
T_6	50 % RDF + Vermicompost @ 3 t ha^{-1} + Pinching at 30 and 60 DAT + Micronutrient mixture @ 0.5 % at 45 DAP
T_7	75 % RDF + Coirpith compost @ 10 t ha^{-1} + Pinching at 30 and 60 DAT + Micronutrient mixture @ 0.5 % at 45 DAP
T_8	50 % RDF + Coirpith compost @ 15 t ha^{-1} + Pinching at 30 and 60 DAT + Micronutrient mixture @ 0.5 % at 45 DAP
T_9	T_5 + Soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP and foliar application of Jeevamrutham @ 5 % at 90 and 120 DAP
T_{10}	T_6 + Soil application of Jeevamrutham @ 10 ml m^{-2} at 30, 60 DAP and foliar application of Jeevamrutham @ 5 % at 90 and 120 DAP
T_{11}	T_7 + Soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP and foliar application of Jeevamrutham @ 5 % at 90 and 120 DAP
T_{12}	T_8 + Soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP and foliar application of Jeevamrutham @ 5 % at 90 and 120 DAP
T_{13}	Control - 100 % RDF (125: 120: 25 kg of NPK ha^{-1}) and without pinching

Results and Discussion

The research study of Chrysanthemum on the influence of pinching and integrated nutrients significantly influenced the growth and flowering parameters. The data and the result on the influence of pinching and integrated nutrients on growth and yield of Chrysanthemum var. Poornima White and their observation recorded on all growth and flowering parameters is present in Table 2 and 3.

Growth Parameters

In the biometric observation on growth parameters *viz.*, plant height (15.75 cm and 56.11 cm at 30 and 90 DAP), number of branches (4.93 and 28.15 at 30 and 90 DAP), number of leaves (32.27 and 135.00 at 30 and 90 DAP), plant spread (40.52 cm in North-South direction and 39.75 cm in East-West direction) and leaf area (33.54 cm^2) were recorded. .In growth parameters were the maximum effect of pinching and integrated nutrients occurred in T_{11} with the application of 75

per cent RDF along with Coirpith compost @ 10 t ha^{-1} with this pinching is carried out at 30 and 60 days after planting along with foliar application of micronutrient mixture @ 0.5 per cent at 45 DAP and soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP and then with foliar spray of Jeevamrutham @ 5 per cent at 90 and 120 DAP and it was followed by treatment (T_9) with the application of 75 per cent RDF + Vermicompost @ 1.5 t ha^{-1} with this pinching is carried out at 30 and 60 days after planting along with foliar application of micronutrient mixture @ 0.5 per cent at 45 DAP and soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP along with foliar application of Jeevamrutham @ 5 per cent at 90 and 120 DAP. The minimum growth parameters were recorded in the treatment T_{13} which was the control (100 % RDF - 125: 120: 25 kg of NPK ha^{-1} and without pinching). The reason for the highest value in the best treatment (T_{11}) could be due to the application of optimum dose of both inorganic and organic fertilizers. Coirpith compost play a vital role in good aeration to plants in order to sustain the growth and development of shoots. Increase in vegetative growth is also due to the adequate availability of nitrogen content in coirpith along with application of 75 per cent of recommended dose of fertilizer which leads to increase in cell number and cell size.

All these vegetative growth of chrysanthemum plants grown in this nutrient combination resembles greater carbohydrate accumulation which in turn increased photosynthesis and simultaneously it maximized the growth of roots and shoots. An increase in number of leaves causes the accumulation of greater photosynthesis leading to better growth parameters. Leaves are the important functional units for photosynthesis, which greatly influence the growth and flower yield of any crop. Implementation of pinching enhanced more side branches which in turn influenced maximum growth and yield. This was due to diversion of carbohydrates or food material towards the auxiliary vegetative buds below pinched portion. The increase in growth parameters was due to foliar application of micro nutrient mixture at appropriate time which might have improved the growth and development of Chrysanthemum. Micronutrient application also enhances photosynthesis and other metabolic activities related to cell division and cell elongation. At the same time soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP at different stages maximized the growth of Chrysanthemum. These results are in conformity with the findings of Singh *et al.* (2015) in Marigold, Mahadik *et al.* (2017) in Chrysanthemum, and Aruneshet *al.* (2020) in Gerbera.

Table 2: Effect of pinching and integrated nutrients on growth parameters of Chrysanthemum (*Dendranthema grandiflora*) var. Poornima White

Treatments	Plant height(cm)		Number of branches		Number of leaves		Plant spread (cm)		Leaf area (cm^2)
	30 DAP	90 DAP	30 DAP	90 DAP	30 DAP	90 DAP	N-S	E-W	
T_1	9.10	45.98	3.99	23.71	24.34	118.92	28.96	28.06	24.01
T_2	9.89	47.18	4.10	24.21	25.27	120.91	30.41	29.48	25.20
T_3	8.28	44.76	3.90	23.16	23.37	116.95	27.49	26.60	22.84
T_4	7.48	43.57	3.83	22.64	22.45	115.00	26.08	25.17	21.69
T_5	13.19	52.10	4.50	26.35	29.06	128.74	36.08	35.26	29.92

T_6	11.54	49.66	4.29	25.25	27.20	124.81	33.23	32.39	27.56
T_7	12.39	50.86	4.37	25.79	28.12	126.79	34.69	33.84	28.72
T_8	10.73	48.43	4.17	24.74	26.22	122.87	31.83	30.92	26.35
T_9	14.85	54.54	4.80	27.42	31.05	132.77	39.01	38.21	32.28
T_{10}	14.11	53.38	4.68	26.91	30.08	130.80	37.59	36.78	31.11
T_{11}	15.75	56.11	4.93	28.15	32.27	135.00	40.52	39.75	33.54
T_{12}	14.02	53.29	4.61	26.88	30.02	130.73	37.51	36.74	31.06
T_{13}	7.41	42.32	3.7	22.08	21.47	113.01	24.62	23.69	20.48
S.ED	0.40	0.60	0.04	0.25	0.46	0.97	0.70	0.71	0.57
CD (P=0.05)	0.80	1.20	0.07	0.50	0.92	1.94	1.39	1.42	1.14

Table 3: Effect of pinching and integrated nutrients on flowering parameters of Chrysanthemum (*Dendranthema grandiflora*) var. Poornima White

Treatments	Days taken to first flower bud appearance (days)	Number of petals flower^{-1}	Duration of Flowering (days)	Flower Diameter (cm)	Single Flower weight(g)
T_1	63.03	180.34	152.11	4.39	2.64
T_2	62.20	181.07	152.88	4.58	2.89
T_3	63.84	179.65	151.33	4.19	2.36
T_4	64.68	178.94	150.58	4.00	2.10
T_5	58.85	183.85	155.87	5.36	3.94
T_6	60.53	182.46	154.36	4.97	3.42
T_7	59.66	183.15	155.09	5.15	3.69
T_8	61.35	181.75	153.60	4.75	3.18
T_9	57.14	185.57	157.51	5.87	4.58
T_{10}	57.96	184.90	156.76	5.66	4.34
T_{11}	56.11	186.24	158.31	6.12	4.87
T_{12}	57.99	184.57	156.61	5.54	4.22
T_{13}	65.55	178.21	149.85	3.78	1.86
S.ED	0.40	0.34	0.36	0.08	0.05
CD (P=0.05)	0.81	0.67	0.72	0.17	0.11

Flowering Parameters

Significant difference was observed due to the application of various treatments. In flower parameters, were the maximum effect of pinching and integrated nutrients are seen in treatment (T_{11}) with the application of 75 per cent RDF along with Coirpith compost @ 10 t ha^{-1} with this pinching is carried out at 30 and 60 days after planting along with foliar application of micronutrient mixture @ 0.5 per cent at 45 DAP and soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP and then with foliar spray of Jeevamrutham @ 5 per cent at 90 and 120 DAP. The minimum days taken for first flower bud initiation (56.11 days) and maximum number of petals $flower^{-1}$ (186.24 petals $flower^{-1}$), maximum duration of flowering (158.31 days), flower diameter (6.12 cm) and single flower weight (4.87 g) were observed in the best treatment T_{11} which had optimum combination of both inorganic and organic nutrients. The minimum performance of flowering attributes was obtained in the control (100 % RDF - 125: 120: 25 kg of NPK ha^{-1} and without pinching). The increase in flowering parameters is might be due to the vigorous growth of the plant growing in organic and inorganic nutrients resulted in rapid uptake of nutrients and water has a pronounce effect on early production of first flower bud appearance and maximum number of petals $flower^{-1}$, maximum duration of flowering.

This is also attributed to accumulation of more photosynthates in coirpith compost along with inorganic nutrients might have induced early flowering and a greater number of petals. Organic nutrients enriched with sufficient organic matter leads to early first flower bud initiation and a greater number of petals. Similar results were reported by Karthikeyan and Jawarharlal (2015) in Carnation and Swarupa *et al.* 2019 in Gerbera, after pinching, application of micronutrient mixture at the right time minimized the days taken for flower bud initiation. Karuppaiah (2019) has reported that the use of foliar application of micronutrient spray led to the increase in amount of chlorophyll in plant leaves. These responses of foliar application of micronutrient mixture encourages the growth and flowering of Chrysanthemum could be related with a constitutive increased net photosynthetic rate due to the high content of chlorophyll and the improved chloroplast ultra-structure. The increase in flower characters *viz.* number of petals $flower^{-1}$, duration of flowering, flower diameter and single flower weight is obtained due to the soil application of organic liquid of Jeevamrutham, it also promotes immense biological activity in the soil and enhances nutrient availability to the crop. Simultaneously, the application of Jeevamrutham to the soil enhanced the activity of microbes by solubilization and uptake of nutrients resulting in improving the flowering parameters. These results are in conformation with the findings of Khandelwal *et al.* (2003) in Marigold, Sendhilnathan *et al*., (2019) in Rose and Thakare *et al*.,(2020) in Chrysanthemum.

Conclusion

Based on the above facts and results of the present studies on the effect of pinching and integrated nutrients for maximization in certain growth and flowering characters of Chrysanthemum var. Poornima White, it is revealed that treatment T_{11} with the application of 75 per cent RDF along with Coirpith compost @ 10 t ha^{-1} with this pinching is carried out at 30 and 60 days after planting along with foliar application of micronutrient mixture @ 0.5 per cent at 45 DAP and soil application of Jeevamrutham @ 10 ml m^{-2} at 30 and 60 DAP DAP and foliar application of Jeevamrutham @ 5 % at 90 and 120 DAP was found to be superior in good growth and profuse flowering than other treatments.

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GRAFTING- EMERGING TECHNOLOGY IN BRINJAL (*Solanum melongena* L.) TO INCREASE THE YIELD AND QUALITY UNDER CHANGING ENVIRONMENT

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Abstract

*Brinjal (Solanum melongena L.) is one of the important vegetable crops which is widely consumed in tropical and sub tropical region of the globe. The production and productivity of brinjal is reduced due to several factors (both biotic and abiotic). Under such circumstances, an alternate and environmentally friendly method which helps to increase the productivity of brinjal is '**Grafting'.** Objective of the study is to identify compatible rootstock with increased yield, resistant to pest, disease and withstand various adverse conditions. The investigation was conducted at College Orchard, Tamil Nadu Agricultural University, Coimbatore, under randomized block design with five wild species of Solanum viz., S. torvum, S. viarum,S. xanthocarpum, S. incanum and S. elaegnifolium along with four cultivable brinjal Hybrid Derivative 1, 2, 3 and a F_1 hybrid COBH 2. Apart from the derivatives twenty-four graft combination was derived by using the above materials. Observations were recorded for all quantitative and qualitative traits. Among twenty-four graft combinations, COBH 2 + S. torvum showed highest yield of 40.13 kg/plant in 30 pickings which can be maintained as perennial type also recorded highest for all quality parameters (15.67mg/g protein, 1.78 mg/g phenol, 16.58 mg/g ascorbic acid and 9.04 % dry matter). Hence COBH 2 + S. torvum can be recommended as a best graft combination for brinjal cultivation under various conditions.*

Key words: Grafting, wild species, Solanum species, Brinjal

Introduction

Brinjal is one of the important vegetable crops universally grown and regional specific crop which is widely consumed in tropical and sub tropical region of the globe. It is a rich source of potassium (2 mg per 100g) and low in calorific value (24 kcal per 100g) which is advisable for obese and diabetic patients. In India, brinjal is predominantly produced in the open field and even sometimes as rainfed crop. Though productivity of brinjal in Indian plains is high, it is reduced largely due to vagaries of weather conditions.

As weather becomes fiercer and storm increases in frequency and intensity, serious socio-economic consequences results. Climate change can seriously affect agricultural production and therefore, food security at present, does not enjoy food security so is very vulnerable to the effects of climate change. Prevailing climate is critical in controlling the ecosystem structure. Extreme weather events such as heavy winds, droughts and floods devastate farm lands and change the microclimate around the crop, which leads to crop failure.

Adverse climatic conditions are primarily responsible for the low productivity of brinjal also pest and crop disease migrate in response to climate variations and will potentially pose a threat to crop production. Due to unfavorable climatic conditions under field conditions getting

quality produce is the main constraint in reaping high return especially during summer production. Incorporating genetic resistance to the biotic stress has not yielded uniform success and thus another technology is needed to supply the product to the existing marketing window. Hence there is an urgent need to develop a technology to overcome this problem under field conditions. Grafting of cultivated eggplant varieties on the related wild species as rootstocks which are resistant to pest and disease is one of the handy methods. The concept behind the grafting technology is to grow brinjal even under adverse climatic condition to increase the productivity. The brinjal grafted with *Solanum torvum* was a potential rootstock because of high resistant to bacterial wilt, root knot nematode and good fruit yield of scion (Mochizuki and Yamakawa, 1979).

Materials and Methods

Studies were conducted at the College Orchard, Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore to elucidate the effect of grafting of brinjal with wild *Solanum* rootstock on growth, yield and quality. The five wild *Solanum* species *Solanum torvum, S. viarum, S. xanthocarpum, S. incanum,* and *S. elaegnifolium* and hybrid derivatives 1, 2, 3 with hybrid COBH 2 were used for grafting. The experiment was laid out in Randomized Block Design with three replications. The grafts were planted with spacing of 1x1 m and maintained with proper package of practices. All the quantitative and qualitative characters were recorded and analyzed statistically as per Panse and Sukhatme (1957).

Result and Discussion

The result revealed that among twenty different graft combinations, *S. torvum* + COBH 2 performed well for growth (Plant height, Number of branches, days to first flowering), yield (fruit length, girth, weight, number of fruits, yield per plant) and quality (Phenols, proteins, ascorbic acid, sugars, and dry matter content) characters. Vigorous plants were observed in the grafts, as reflected in higher plant height, more branches and large stem diameter than non- grafted plants. This would be attributed to larger and vigorous root growth of the rootstock *S. torvum*. Taller plant produced a greater number of branches and resulted in more vegetative vigour which would have recorded increased photosynthetic rate and accumulation of photosynthates contributing towards yield (Bletsos, 2006 and Rashid *et al*., 2005). The combination *S. torvum* + COBH 2 recorded highest value for fruit length, girth, weight, number of fruits, yield per plant and total number of harvests.

The species *S. torvum* excelled for these entire traits because higher root length would have favoured translocation of more food material to the plant canopy resulting in the increase yield. Possible mechanisms for increased crop productivity could be increased water and nutrient uptake by vigorous rootstock type, stomatal conductance there by increased crop growth (Ruiz *et al*., 1996, Leonardi and Giuffrida, 2006), controlled uptake, synthesis and translocation of water, mineral and plant hormones (Lee and Oda, 2003) and enhanced photosynthates (Hu *et al*., 2006)

The quality parameters *viz*., phenol, ascorbic acid, protein, dry matter content, sugars content was increased in the graft combination *S. torvum* + COBH 2 as compared to control. The results indicated that the grafting had influence on the biochemical aspects of brinjal cultivars. All the quality related parameters such as phenol, protein and ascorbic acid content increased as compared to control (cultivars), whereas the combination registered lower value for the same as compared to rootstock indicating the quality of the fruit is determined by the scion and not the rootstock. However, the improvement in quality by the scion in the grafting should be assessed in detail in the future studies. In the present study, except non reducing sugar, all the parameters

showed enhanced quantity as compared to scion. Whereas the solasodine content showed reduction in the cultivars over control indicating that the grafting influenced negatively on solasodine content. The similar report has been opined by Oda *et al.* (1996) in tomato that differential impact of grafting on quality parameters. Considering the rootstock, the solasodine value was found higher as compared to grafting indicating that both scion and rootstock influenced negatively. The similar trend was observed for phenol, OD phenol, protein, and ascorbic content also that quality parameter improvement is due to neither scion nor rootstock effect. Ali *et al*. (1992) also confirmed the present finding that the susceptible factor of the grafted scion was not transmitted across the graft union to the rootstock.

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Table 1. Performance of grafts and scion on number of fruits per plant, fruit yield per plant and total number of harvests in brinjal

Treatment	Number of fruits per plant	Fruit yield per plant (kg)	Total number of harvests
HD 1+ *S. torvum*	238.00	20.67	28.20
HD 2+ *S. torvum*	193.60	12.56	26.30
HD 3+ *S. torvum*	218.80	17.31	27.20
COBH 2+ *S. torvum*	350.20	40.13	30.00
HD 1+ *S. viarum*	64.70	2.64	21.76
HD 2+ *S. viarum*	34.50	1.93	21.23
HD 3+ *S. viarum*	50.80	2.21	21.45
COBH 2+ *S. viarum*	71.90	3.45	23.33
HD 1+ *S. xanthocarpum*	194.60	11.54	25.60
HD 2+ *S. xanthocarpum*	141.80	7.31	25.50
HD 3+ *S. xanthocarpum*	158.00	9.77	25.40
COBH 2+ *S. xanthocarpum*	277.50	21.48	25.80
HD 1+ *S. incanum*	201.40	13.86	25.70
HD 2+ *S. incanum*	143.00	9.88	25.52
HD 3+ *S. incanum*	151.30	10.10	25.48
COBH 2+ *S. incanum*	298.20	22.52	25.64
HD 1+ *S. elaegnifolium*	72.70	3.98	20.40
HD 2+ *S. elaegnifolium*	46.50	2.55	18.30
HD 3+ *S. elaegnifolium*	65.90	3.36	21.70
COBH 2+ *S. elaegnifolium*	97.40	4.36	23.25
Hybrid Derivative 1	86.80	8.48	25.78
Hybrid Derivative 2	97.40	5.41	25.89
Hybrid Derivative 3	79.90	6.32	25.76
COBH 2	108.00	10.53	26.52
Grand mean	143.45	10.51	24.63
SEd	5.78	0.47	0.49
CD (P=0.05)	11.64	0.95	0.99

Table 2. Biochemical constituents in fruits of brinjal grafts, scion and rootstocks

Treatment	Reducing sugar (Mg g^{-1})	Non-reducing sugar (Mg g^{-1})	Total sugar (Mg g^{-1})	Polyphenol oxidase (Changes in OD min^{-1} g^{-1} of sample)	Solasodine (%)
HD 1+ *S. torvum*	3.50	6.80	10.30	0.395	0.040
HD 2+ *S. torvum*	4.00	7.10	11.10	0.389	0.031
HD 3+ *S. torvum*	3.49	6.83	10.32	0.405	0.042
COBH 2+ *S. torvum*	3.41	6.45	9.86	0.447	0.030
HD 1+ *S. viarum*	3.58	7.26	10.84	0.385	0.043
HD 2+ *S. viarum*	4.10	7.28	11.38	0.375	0.035
HD 3+ *S. viarum*	3.54	7.02	10.56	0.394	0.046
COBH 2+ *S. viarum*	3.49	6.66	10.15	0.424	0.032
HD 1+ *S. xanthocarpum*	3.55	6.95	10.50	0.391	0.045
HD 2+ *S. xanthocarpum*	4.09	7.11	11.20	0.382	0.041
HD 3+ *S. xanthocarpum*	3.64	7.05	10.69	0.399	0.048
COBH 2+ *S. xanthocarpum*	3.48	6.52	10.00	0.430	0.033
HD 1+ *S. incanum*	3.52	6.97	10.49	0.393	0.047
HD 2+ *S. incanum*	4.03	7.16	11.19	0.384	0.042
HD 3+ *S. incanum*	3.60	6.83	10.43	0.400	0.048
COBH 2+ *S. incanum*	3.45	6.48	9.93	0.435	0.032
HD 1+ *S. elaegnifolium*	3.62	7.02	10.64	0.389	0.042
HD 2+ *S. elaegnifolium*	4.13	7.19	11.32	0.377	0.039

HD 3+ *S. elaegnifolium*	3.71	7.04	10.75	0.397	0.046
COBH 2+ *S. elaegnifolium*	3.51	6.74	10.25	0.426	0.038
Hybrid Derivative 1	3.54	6.98	10.52	0.390	0.041
Hybrid Derivative 2	4.06	7.18	11.24	0.381	0.038
Hybrid Derivative 3	3.52	7.16	10.68	0.398	0.042
COBH 2	3.40	6.65	10.05	0.425	0.039
S. torvum	3.88	5.61	9.49	1.096	1.920
S. viarum	4.10	5.40	9.50	0.546	1.924
S. xanthocarpum	5.81	6.99	12.80	0.808	2.248
S. incanum	6.81	4.00	10.81	0.876	2.259
S. elaegnifolium	5.24	6.76	12.00	0.612	2.198
Grand mean	3.89	6.78	10.67	0.467	0.397
SEd	0.09	0.13	0.22	0.10	0.02
CD (P=0.05)	0.18	0.27	0.43	0.02	0.04

ENVIRONMENTAL SAFETY OF PULSED ELECTRO MAGNETIC EXPOSURE SEED TREATMENTS AND ANALYSIS PHYSIOLOGICAL, BIOCHEMICAL ACTIVITY OF SEED STORABILITY IN BLACKGRAM

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Abstract

Superior storage is the basic requirement in seed production programme as maintenance of high seed viability and vigour from harvest to planting is of utmost importance in seed storage. Therefore, inexpensive, effortless, and realistic technology to extend the shelf life of seeds under ambient condition is immensely needed. Moreover, a cost-effective treatment is to be evolved for blackgram seed storage where Callosobruchuschenens is caring qualitative and quantitative loss. Hence, an experiment was conducted at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore during 2021, to study the effect of pulsed electromagnetic exposure with a strength of 500 nT, 750 nT and 1500 nT on the seeds for 5 hr per day for 15 days at different combinations of exposure under ambient conditions. The seed without electromagnetic exposure was considered as control. The treated and untreated seeds were stored in cloth bag and super grain bag. The results revealed that, pulsed electromagnetic exposure on seeds were significantly superior in controlling the storage insect and maintaining higher seed quality up to nine months of storage when compared to control. Among the treatments, the 500 nT + 750 nT strength and seeds packed in super grain bag found better by recording significantly higher germination percentage (92%), dehydrogenase activity (1.729) lower moisture content (8.7%), electrical conductivity (52.8 µS cm-1 g-1) when compared to control at the end of nine month of storage and the treatment had been considered as effective seed storage management approach in blackgram seeds.

***Keywords**: Blackgram, Containers, Physiological, Biochemical parameters and Electromagnetic Exposure.*

Introduction

Blackgram (*Vignamungo* (L.) Hepper) belongs to Leguminaceae family occupies a unique place amongpulses for its use as seed and vegetable and it is grown both as pure and mixed crop. Since it is native to India, suppliments the income of many small-scale farmers and contributes to the maintance of soil fertility by fixing nitrogen in the soil. Blackgram is considered as one of the rich protein foods, contains about 26 % protein, 1.2% fat and 56.6% carbohydrates on dry weight basis and it is rich source of calcium and iron considering the importance and to augment the productivity of blackgram crop quality seeds play a major role. The quality of seeds in storage is influenced by several factors like variety of seed, initial seed quality, storage condition, moisture

content, insect pest, bacteria, and fungi. Blackgram itself is microbiotic in nature and the poor storability is due to infection of *Callasobruchuschenensis* (L.) and *C. maculates* (F.) of *Bruchidae*family, which causes qualitative and quantitave losses. Therefore, maintenance of seed viability and vigour during storage is a matter of prime concern. Maintenance of seed quality during storage period is important not only for successful crop production but also for maintaining the quality and integrity of the seed that are inconstant threat of genetic erosion (Barua*et al.*, 2009). Duruigbo, (2018) reported that pulsed electromagnetic exposure can also reduce the infestation of *Callasobruchuschenensis*there by the storability of blackgram seeds can also be improved. Therefore, an experiment was made to study the influence of pulsed electromagnetic seed treatment on storability of blackgram seeds under ambient conditions.

Materials and Methods

The experiment was carried under ambient conditions (mean temperature 28 ± 2°C and RH 70 ± 2%) at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore during 2020-2022. The experiment was laid out in completely randomized block design with four replications. The blackgram seeds var.VBN (Bg) 6 were collected from National Pulses Research Centre, Pudukkottai, Tamil Nadu as fresh, dried to the recommended safe moisture content of 8 per cent . The seeds were packed in cloth bag and super grain bag makes the principle of hermetic storage available to farmers at low cost. The IRRI Super Bag is afarmer-friendly storage bag that allows cereal grains and other crops (e.g., maize or coffee) to be safely stored from 6 to 12 months and control insect grain pests (without using chemicals). It is resalable, airtight, moisture-proof safe and transportable storage container for dry commodities. Seed samples were exposed under pulsed electromagnetic using (Biotron device) for the following magnetic electro wavelength and duration.

PulsedElectromagneticExposure-BIOTRONDEVICE

Figure1

Table1

Treatments	MagneticFieldStrength	Duration
T_0	Control	
T_1	500^nT	5hrper dayfor 15days.
T_2	750^nT	5hr perdayfor15 days
T_3	1500^nT.	5hr perdayfor15 days
T_4	500^nT+750^nT	Each5 hr per dayfor 15 days
T_5	$750^nT+1500^nT$.	Each5 hr per dayfor 15 days
T_6	$500^nT+1500^nT$.	Each5 hr per dayfor 15 days

The seeds without magnetic wavelength exposure were treated as control. After the treatment seeds in both cloth bag and super grain bag were stored under ambient conditions (temperature 28 ± 2oC and RH 70 ± 2%). Data were collected on seed samples drawn from each treatment on moisture content (%), seed germination (%), dehydrogenase activity (OD) and electrical conductivity (µS cm-1 g-1) at monthly intervals upto nine months.

Physiological and biochemical activity

Five gram of ground seed material was placed in a moisture weighing bottle and kept in a hot air oven maintained at 130 ± 20 C for 1 h for drying and cooled in a desiccator containing silica gel for 30 min. The weight of seeds along with moisture bottle before and after drying was recorded in the gram. The moisture content was calculated using following formula and expressed as percentage (ISTA, 2011). Where, **M1** – Weight of moisture weighing bottle alone, **M**2 – Weight of moisture weighing bottle + seed sample before drying, **M3** – Weight of moisture weighing bottle + seed sample after drying.

Germination test was conducted by following the Seed Testing Rules outlined in ISTA (2011) with roll towel medium using 4 x 100 seeds in a germination room maintained at 25 ± 2°C temperature and 95 ± 3 % RH. After the seven days, the seedlings were evaluated. Based on normal seedlings, the germination was calculated adopting the following formula and the mean expressed as percentage. Four replicates of fifty seeds were drawn from each treatment and container prewashed well with distilled water and then soaked in 75 ml of distilled water for duration 6 h (Sathesh, 2013) at room temperature. After soaking, the seed steep water was decanted to obtain the seed leachate. Randomly selected twenty-five seeds were preconditioned by soaking in water for 6 h. Then the seeds were bisected longitudinally into two halves and were steeped in 0.1 % 2, 3, 5 triphenyltetrazolium chloride solution and kept in dark for2 h at 40°C for staining. After staining, the excess solution was drained and the seeds were washed thoroughly withdistilled water and transferred to a test tube containing 5 ml of 2-methoxy cellosolve. The coloured solution was decanted and the colour intensity was measured using Cary UV spectrophotometer at 470nm and methyl cellosolve as the blank (Kittock and Law, 1968). The OD values obtained were from each treatment reported as total dehydrogenase activity.

The experimental data were analyzed using the Statistical, according to the completely randomized design. Values were compared by three-way analysis of variance (ANOVA) and mean differences were determined using the least significant difference, at the 5% level of significance.

Results and Discussions

Moisture content of stored seeds was significantly influenced by seed treatment, container, storage period and their interaction (Table 2). Irrespective of period of storage and container, after nine months of storage seed treatment with 500 nT + 750 nT for 5 h for 15 days significantly lowered the increase of seed moisture content of 8.7 per cent compared to control seeds (9.6 per cent). Between the containers, seed stored in super grain bag registered the lowest moisture of 8.7%than cloth bag (9.5%). The interaction between treatment and period of storage revealed that the seed treatment with 500 nT + 750 nT for 5h for 15 days registered the lower moisture of 9.1 per cent at followed by 500 nT + 1500 nT (9.4 %) at the end of the nine months of storage while the untreated control seeds recorded the highest moisture of 10.3 per cent by absorbing atmospheric moisture (Table.2). The period and container of storage expressed that seed stored in super grain bag sustained slight increase in moisture content from 8.1% (P1) to 8.7% (P9). Cloth bag being a

pervious nature moisture exchange took place frequently until it reaches the equilibrium status with environment where as super grain bag is impervious as accordance with the results by Jeya*et al*. (2014). Similar findings were reported by Lei Zhang *et* al. (2015) in spinach. Cloth bag being a pervious container, moisture exchange took place frequently until it reached the equilibrium status with environment, thereby this recorded higher moisture at the end of storage period. Super-grain bag which may be attributed to the impervious nature to moisture vapours and thus it has caused less fluctuation in seed moisture content and it eliminates dampness, deterioration, microorganisms and enhance the seed longevity. These findings were in conformity with the results of ShanthappaTirakannanavar and Ramaiah (2006) in redgram and Basavegowda*et al.* (2013) in chickpea whoreported that less fluctuation in seed moisture in the impervious packaging materials as compared to cloth bag. Germination percentage of stored seeds in irrespective of period of storage and container, with the treatment of 500 nT + 750 nT for 5h for 15 days recorded significantly higher germination of 92 per cent compared to untreated control seeds (80 per cent). Between the containers, seed stored in super grain bag registered the highest germination of 92% than cloth bag (85%). The interaction between treatment and period of storage revealed that the seed treatment with 500 nT + 750 nTfor 5h for 15 days registered the higher germination of 89 per cent followed by 500 nT + 1500 nT(86 per cent) at the end of the nine months of storage while the untreated control seeds recorded the lowest germination of 77 per cent (Table. 3). The period and container of storage expressed that seed stored in super grain bag-maintained germination from 100% (P1) to 92% (P9), during storage. Generally free radicals are atoms, molecules, or ions with unpaired electrons, which are highly reactive to chemical reactions with other molecules, in the biology system. Antioxidant protects and prevents oxidative deterioration of lipids and maintains structural and functional integrity of cells. Better membrane integrity in treated seeds by the antioxidant enzyme during storage period, could be one of the reasons for maintain of germination in the treated and seeds packed in super grain bag. The electrical conductivity was lowest in seeds treated with T4 - 500 nT + 750 nT seeds (52.8µS cm-1 g-1) in super grain bag at the end of nine months of storage compared to cloth bag (57.6 cm-1 g-1) [Figure-2]. The interaction between treatment and period of storage revealed that the seed treatment with 500 nT + 750 nT registered the lower electricalconductivity of (55.3 µS cm-1 g-1) at followed by 500 nT + 1500 nT (55.9 µS cm-1 g-1) at the end of the nine months of storage while the untreated control seeds recorded the highest electrical conductivity of (59.4 µS cm-1 g-1) [Table-3]. The variation in electrical conductivity of seed leachate indicates increased membrane permeability and decreased compactness of seed coat and cellular membrane deterioration; stable cell membrane also rendered resistance to peroxidase and free radical reactions. Similar, findings in groundnut. Decrease in enzymatic activity in stored seeds with increase in storage period resulted reduction in germination and vigour as reported by Khan *et al.,* 2013. Chen and Zhou (1990) observed similar increase in electrical conductivity, soluble sugar, and amino acids with ageing of rice hybrids. When the seed storage period prolonges leachate from the seeds also increased during ageing process and thus seed quality decreased. This might be due to faster deterioration of cellmembrane and oxidation of polyunsaturated fatty acids in the membrane lipid compounds involving free radical chainreaction (Srivastava, 1975). Loss of membrane integrity during storage would be the main reason for increased electrical conductivity and evidenced by structural change and changes in membrane composition (Delouche and Baskin, 1973). The dehydrogenase activity was highest in seeds treated with 500 nT + 750 nT (1.729) in super grain bag at the end of nine months of storage compared to

cloth bag (1.658) [Figure-3]. The interaction between treatment and period of storage revealed that the seed treatment with 500 nT + 750 nT registered the higher dehydrogenase activity of (1.694) at followed by 500 nT + 1500 nT (1.675) at the end of the nine months of storage while the untreated control seeds recorded the lowest dehydrogenase activity of (1.497) [Table-4]. The marked decrease in the seed quality parameters under advancing period of storage may be attributed to seed coat characters, age induced physicochemical seed deterioration, lipid peroxidation leading to production of toxic metabolites that may denature of proteins and enzymes of cell and cell organelles. Similar result was reported by Pramila (2003) in black gram.

According to Labes, (1966) it is evident that magnetic fields influence the structure of the cell membrane and increase of permeability and ion transport in the ion channels, which may affect the metabolic pathway Changes in theintracellular level of Ca 2þ and ionic current density across the cellular membrane alters the osmotic pressure and changes the capacity of cellular tissue to absorb water (Garcıa-Reina and Arza-Pascual, 2001). The magnetic exposure dose response studies on seed characters showed that 150 and 200 mT fields for 60 and 90 min significantly enhanced seedling parameters in various crops.

Conclusions

It is evident from the present investigation that the seed stored in moisture pervious container of cloth bag showed poor quality parameter of decreased germination where is evident from lowest dehydrogenase activity and higher EC value due to increase seed quantitative losses and greater fluctuations in moisture content due to permeable nature of cloth bag to moisture vapours. The strength pulsed electromagnetic exposure with 500 nT + 750 nT, 500 nT + 1500 nT and stored insuper grain bag were considered as effective seed storage management approach in blackgram. Among the seed treatments, exposure with electromagnetic wavelength of with 500 nT + 750 nT recorded higher seed quality parameters throughout the storage period and packed in super grain bag-maintained seed quality above the minimum seed certification standards up to nine months, proved that one of the safest, economical, eco-friendly and non-harmful approach of seed management tomaintain the germination and other quality parameters of blackgram during storage.

Figure 2: Influence of Pulsed Electromagnetic Treatments, Storage Containers and Period of Storage onElectricalConductivity ($\mu Scm^{-1}g^{-1}$) of BlackgramVBN (Bg)

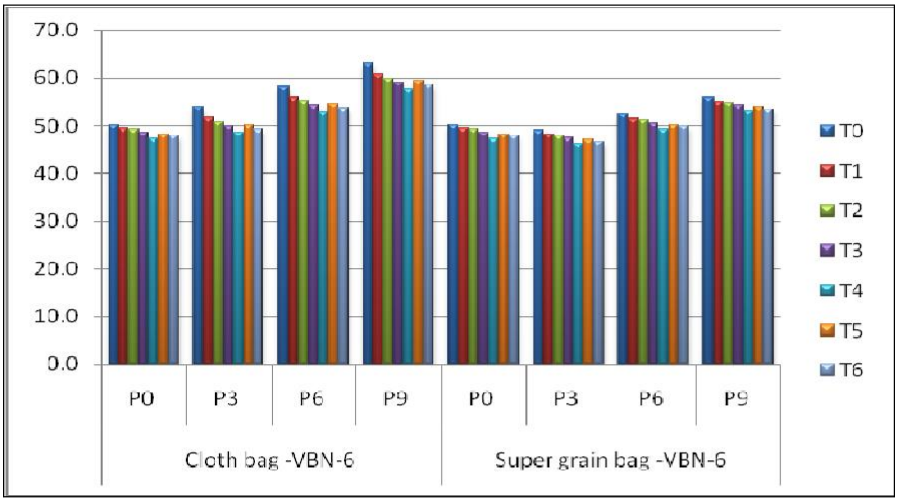

Figure 3: Influence of Pulsed Electromagnetic Treatments, Storage Containers and Period ofStorageon Dehydrogenase Activity(ODvalue) ofBlackgramVBN (Bg)6

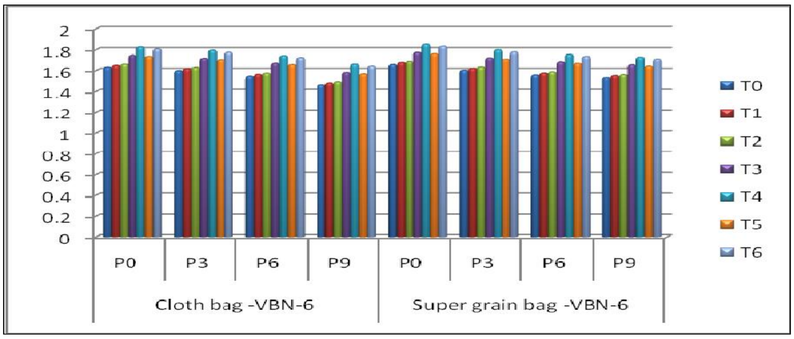

Table 2: Influence of Pulsed Electromagnetic Treatments, Storage Containers and Periodof Storage onMoisture Content (%) ofBlackgramVBN (Bg) 6

PeriodofStorage(P)inMonths										
Treatments(T)	**ClothBag**					**Super GrainBag**				
	P_0	**P_3**	**P_6**	**P_9**	**MEAN**	**P_0**	**P_3**	**P_6**	**P_9**	**MEAN**
T_0	8.1	8.6	9.5	10.9	**9.3**	8.1	8.4	9.0	9.6	**8.8**
T_1	8.1	8.4	9.3	9.4	**8.9**	8.1	8.3	8.7	9.2	**8.6**
T_2	8.1	8.4	9.3	9.4	**8.9**	8.1	8.3	8.8	9.1	**8.6**
T_3	8.1	8.3	9.0	10.1	**8.9**	8.1	8.2	8.6	8.8	**8.4**
T_4	8.1	8.2	8.7	9.5	**8.6**	8.1	8.1	8.4	8.7	**8.3**
T_5	8.1	8.4	9.1	10.2	**9.0**	8.1	8.2	8.7	9.1	**8.5**
T_6	8.1	8.3	8.9	9.8	**8.8**	8.1	8.2	8.6	8.9	**8.5**
Mean	**8.1**	**8.4**	**9.1**	**9.9**		**8.1**	**8.2**	**8.7**	**9.1**	
TXP	**P_0**	**P_3**	**P_6**	**P_9**	**MEAN**					
T_0	8.1	8.5	9.3	10.3	**9.0**					
T_1	8.1	8.4	9.0	9.3	**8.7**					
T_2	8.1	8.4	9.1	9.2	**8.7**					
T_3	8.1	8.3	8.8	9.5	**8.7**					
T_4	8.1	8.2	8.6	9.1	**8.5**					
T_5	8.1	8.3	8.9	9.7	**8.7**					
T_6	8.1	8.3	8.8	9.4	**8.6**					
Mean	8.1	8.3	8.9	9.5						
	T	**P**	**C**	**TxP**	**PxC**	**TxC**	**TxPxC**			
SEd	0.038	0.029	0.020	0.077	0.041	0.055	0.110			
CD(P=0.05)	0.076	0.058	0.041	0.153	0.082	0.108	0.217			

To-Control, T1-500 ^{n}T, T_2- 750 ^{n}T, T_3- 1500 ^{n}T. T_4- 500 ^{n}T + 750 ^{n}T,T_5-750^{n}T+1500^{n}T,T_6-500^{n}T+1500^{n}T**.**

Table 3: Influence of Pulsed Electromagnetic Treatments, Storage Containers and Periodof Storageon Germination(%)of BlackgramVBN(Bg) 6

PeriodofStorage(P)inMonths										
Treatments(T)	**ClothBag**					**Super GrainBag**				
	P_0	**P_3**	**P_6**	**P_9**	**MEAN**	**P_0**	**P_3**	**P_6**	**P_9**	**MEAN**
T_0	97 (80.03)	92 (73.57)	79 (62.73)	74 (59.34)	**86** (68.03)	97 (80.03)	93 (74.66)	83 (65.65)	80 (64.43)	**88** (69.73)
T_1	97 (80.03)	94 (75.84)	82 (64.90)	78 (62.03)	**88** (69.73)	97 (80.03)	95 (77.08)	86 (68.03)	83 (65.65)	**90** (71.57)
T_2	97 (80.03)	94 (75.84)	83 (65.65)	79 (62.73)	**88** (69.73)	97 (80.03)	95 (77.08)	87 (68.67)	84 (66.42)	**91** (72.54)
T_3	97 (80.03)	95 (77.08)	88 (69.73)	80 (63.43)	**90** (71.57)	97 (80.03)	96 (78.46)	92 (73.57)	89 (70.63)	**94** (75.82)
T_4	100 (90.00)	98 (81.87)	93 (74.66)	85 (67.21)	**94** (75.82)	100 (90.00)	99 (84.26)	96 (78.46)	92 (73.57)	**97** (80.03)
T_5	97 (80.03)	96 (78.46)	86 (68.03)	83 (65.65)	**91** (72.54)	97 (80.03)	97 (80.03)	90 (71.57)	86 (68.03)	**93** (74.66)
T_6	100 (90.00)	97 (80.03)	90 (71.57)	82 (64.90)	**92** (73.57)	100 (90.00)	98 (81.87)	94 (75.82)	90 (71.57)	**96** (78.46)
Mean	**98** (81.87)	**95** (77.08)	**86** (68.03)	**80** (63.43)		**98** (81.87)	**96** (78.46)	**90** (71.57)	**86** (68.03)	
TXP	**P_0**	**P_3**	**P_6**	**P_9**	**MEAN**					
T_0	97 (80.03)	93 (74.66)	81 (64.16)	77 (61.34)	**87 (68.87)**					
T_1	97 (80.03)	95 (77.08)	84 (66.42)	81 (64.16)	**89 (70.63)**					
T_2	97 (80.03)	95 (77.08)	85 (67.21)	82 (64.90)	**90 (71.57)**					

T_3	97 (80.03)	96 (78.46)	90 (71.57)	85 (67.21)	**92 (73.52)**					
T_4	100 (90.00)	99 (84.26)	95 (77.08)	89 (70.63)	**96 (78.46)**					
T_5	97 (80.03)	97 (80.03)	88 (69.73)	85 (67.21)	**92 (73.57)**					
T_6	100 (90.00)	98 (81.87)	92 (73.57)	86 (68.03)	**94 (75.82)**					
Mean	**98 (81.87)**	**96 (78.46)**	**88 (69.73)**	**83 (65.65)**						
	T	**P**	**C**	**TxP**	**PxC**	**TxC**	**TxPxC**			
SEd	0.446	0.337	0.238	0.893	0.477	0.631	1.263			
CD(P=0.05)	0.882	0.666	0.471	1.764	NS	1.247	2.495			

(Figures in paren thesis indicate arcsine values)

To-Control, T1-500 ^{n}T, T_2- 750 ^{n}T, T_3- 1500 ^{n}T. T_4- 500 ^{n}T + 750 ^{n}T,T_5-750^{n}T+1500^{n}T,T_6-500^{n}T+1500^{n}T.

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SHELF LIFE ENHANCEMENT OF *Azospirillum lipoferum* BIOINOCULANT IN LIQUID FORMULATION WITH DIFFERENT CHEMICAL AMENDMENTS

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Abstract

Biofertilizers manufactured in India are generally carrier based with as lignite, Peat, vermiculite, or charcoal as carriers. Despite nearly three decades of existence of biofertilizers in the country supported by various central and state government schemes, the adoption level of biofertilizers among farmers remains low. There are many reasons for such a low adoption of this technology, which are relavent to technological, developmental, and social issues. Azospirillum is one of the important biofertilizer, which is found to fix nitrogen in association with world's most staple food crops like rice, maize, sorghum, wheat, and millets. Apart from routine carrier based biofertilizers, the liquid bioinoculants performed better and gaining importance in the current market. Besides other parameters the self life of the liquid-based formulation must be addressed for the successful adaptation of this technology. Thus, the survival of Azospirillum lipoferum in liquid formulation blended with various concentration of different chemical amendments such as Trehalose, Polyvinyl pyrollidone (PVP) and glycerol were studied for the period of six months and at the end of sixth month of storage Trehalose 15mM supported the highest population of 10.01 Cfu m^{-1} *followed by glycerol 15mM and PVP 2% compared to control.*

Keywords: *Azospirillum, shelf life, Trehalose, Polyvinyl pyrollidone (PVP) and glycerol*

Introduction

Azospirillum is one of the important biofertilizer, which is found to fix nitrogen in association with world's most staple food crops like rice, maize, sorghum, wheat, and millets. Members of the genus *Azospirillum* are widespread in soils and its inoculation of cereal and forage crops resulted in yield increases in many field experiments (Boddey and Dobereiner, 1988), not only due to the nitrogen fixation and through the production of plant growth promoting substances (Tien *et al.*, 1979).

One of the main problems in inoculant technology is the survival of microorganisms during storage and several parameters such as the culture medium, physiological state of the microorganisms when harvested (Chen and Alexander, 1973) the process of dehydrates, rate of drying (Mary *et al.*, 1985), the temperature of storage and water activity of the inoculum (Hahn-Hagerdal, 1986) have an influence on their shelf life. So studies to increase the shelf life of inoculants or finding alternate formulations for carrier based inoculants are important.

Formulation of biofertilizer plays a vital role in helping to solve these problems and in making an organism effective in the field. However, this must be achieved in a cost-effective manner so that product must survive commercially. Formulation aids in preserving organisms and in delivering them to their target fields and once-there in improving their activities. There are varieties of formulation both liquid and solid. The carrier based biofertilizers suffers from minimal shelf life, low quality, maximum contamination, and poor field performance. On the other hand, liquid microbial inoculants are specialized formulations containing the desired microorganisms along with their nutrients, special cell protectants or substances that encourage formation of resting spores or cysts for longer shelf life and tolerance to adverse conditions and effective field performances.

Therefore, it is need of the hour to focus on liquid-based formulation of bioinoculants, with enhanced self-life that has more advantages over conventional carrier-based formulations.

Materials and Methods

Chemical amendments:

N_2 liquid-based formulation with free malate (Nfb) broth was tried in combination with different chemical amendments to increase the survival of *Azospirillum* cells in a liquid formulation. To standardize the optimum quantity of the amendments, the chemicals like trehalose at 5,10,15 and 20mM, polyvinyl pyrollidone (PVP) at 0.5,1.0,2.0 and 2.5% and glycerol at 5,10,15 and 20 mM were added to one liter of N free malate broth separately. One ml of log phase culture of the desired organism *Azospirillum lipoferum* was inoculated individually in each broth with different concentration of chemical amendments. Control (without any chemical addition) was also maintained, and the flasks were incubated at room temperature. The broth cultures were analyzed for viable cell population at 1 month interval up to 6 months.

Enumerating the viable cell population:

The NFb medium was prepared, sterilized and plated in sterile petri plates. The plates were kept at room temperature for 48 hours. Eight equal sectors on the outside bottom of the petri dishes were radially marked.

Four sectors were used for replications of one dilution and four for another, allowing two dilutions per plate. Serial dilutions were prepared by transferring of 1 ml each of inoculum into 9 ml sterile water blanks to get 10^{-1} dilutions. Similarly, the dilutions were made serially up to 10^{-9}. From the dilutions, 5µl was pipetted out and placed on the respective quadrant in the petri plate. The plates were incubated at 28 ± 1^0 C without any disturbance and individual colonies were counted through this drop plate method.

Experimental Results

To increase the shelf life of *Azospirillum* cells in the liquid inoculant that contain chemical amendments *viz*., Trehalose, Polyvinylpyrollidone (PVP) and glycerol were added as supplements to the N_2- free Malic acid (Nfb) broth was studied, and the results were given in Tables 1, 2 and 3.

The effect of chemical amendment Trehalose at different concentrations *viz*., 5 mM, 10 mM, 15 mM and 20 mM on the survival population of *A. lipoferum* in the liquid formulation were studied and given in Table 1. The results revealed that, the *A. lipoferum* population ranged from 10.83 to 10.97 Cfu ml^{-1} on 1st month of storage there after a gradual decrease in population were noted in all treatments. At the end of 6th month, the treatment with 15 mM recorded a maximum population of 10.01 Cfu ml^{-1} and a minimum population of 7.58 Cfu ml^{-1} was recorded with the treatment 5 mM concentration.

The effect of chemical amendment Glycerol at different concentrations *viz*., 5 mM, 10 mM, 15 mM and 20 mM on the survival population of *A.lipoferum* in the liquid formulation were studied and given in Table 2. The results revealed that, the *A.lipoferum* population ranged from 10.42 to 10.93 Cfu ml^{-1} on 1st month of storage there after a gradual decrease in population were noted in all treatments. At the end of 6th month, the treatment with 15 mM recorded a maximum population of 10.00 Cfu ml^{-1} and a minimum population of 6.58 Cfu ml^{-1} was recorded in the treatment with 5 mM concentration.

The effect of chemical amendment Polyvinyl pyrollidone (PVP) at different concentrations *viz*., 0.5 %, 1.0 %, 2% and 2.5% on the survival population of *A.lipoferum* in the liquid formulation were studied and given in Table 3. The results revealed that, the *A.lipoferum* population ranged

from 10.03 to 10.86 Cfu ml^{-1} on 1^{st} month of storage there after a gradual decrease in population were noted in all treatments.

At the end of 6^{th} month, the treatment with 2% recorded a maximum population of 9.96 Cfu ml^{-1} and a minimum of 4.73 Cfu ml^{-1} was recorded in the treatment with 0.5 % concentration.

Among the different chemical amendments, the Trehalose supplemented broth maintained the highest population of *Azospirillum* throughout the period of study, when compared to other treatments and to the control treatment. The treatment with addition of Trehalose at 15mM concentration recorded the highest population of 10.01 Cfu ml^{-1}. Hence 15mM concentration of Trehalose was found to be optimum and was suggested as the best chemical amendment for enhancing the shelf life and might have effective field performance.

Discussion

In the present study, to increase the shelf life of *Azospirillum* cells in the liquid-based inoculants, certain chemicals *viz.,* Trehalose, polyvinyl pyrollidone (PVP) and glycerol were added as amendment to the N_2-free Malic acid (Nfb) broth. Among the chemicals, Trehalose amended broth at 15mM concentration maintained the highest population of *Azospirillum* throughout the period of study, when compared to other treatments and to the control. As Trehalose is an enigmatic compound which acts as a reserve carbohydrate that may be mobilized during the stress (Hounsa *et al.,* 1998). Trehalose is widely reported to enhance cell tolerance to desiccation and to osmotic and temperature stress (Streeter, 1985). It acts by stabilizing both enzymes and cell membrane (Fillinger *et al.,* 2001). The possible effects of Trehalose to the cell may induce the synthesis of metabolites that protect against stress (Gomaz Zavaglia *et al.,* 2003) which might be the reason for the larger number of cells in the Trehalose treatments. Following Trehalose, the treatment amended with 15 mM Glycerol supported the next greatest number of *Azospirillum* cells in the liquid formulation. As Glycerol has a high-water binding capacity and may protect cells from the effect of desiccation by slowing the by slowing the rate of drying (Gorda *et al.,* 1996).

Further, the treatment with 2% PVP gave a marginal increase in population compared to control, the higher population of *Azospirillum* in these treatments might be due to due to its high water binding capacity Suresh babu *et al.,* 2002.

To development a liquid formulation of *Azospirillum* the N free Malic acid (Nfb) broth was amended with Trehalose (15 mM), glycerol (15mM) and PVP (2%) separately. The addition of these chemical amendments allowed the maintenance of a population of 10^8 cells for up to 6 months of storage. Among the amendments Trehalose supported the largest number of *Azospirillum* cells throughout the observation period followed by glycerol and PVP. Similarly, liquid formulation of *Rhizobium* by adding various additives in the yeast extract mannitol media and recorded highest cell number of $1X10^{10}$ cells/ml in the liquid inoculants as reported by Singlaton *et al*., (2002). Further, the increased survival of *Azospirillum* cells in the liquid formulation based might be due to the action of various chemical amendments added in the medium.

Conclusion

The survival of *Azospirillum lipoferum* in liquid formulation with different chemical amendments like trehalose, polyvinyl pyrollidone (PVP) and glycerol in different concentrations were studied. Further it could be concluded that, at the end of sixth month of storage period the liquid formulation amended with Trehalose 15mM supported the highest population of 10.01 Cfu m^{-1} followed by glycerol 15mM and PVP 2% compared to control.

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TABLE 1. EFFECT OF DIFFERENT CONCENTRATION OF TREHALOSE ON THE SURVIVAL OF *Azospirillum lipoferum* UNDER LIQUID FORMULATIONS

Month	Population of *Azospirillum lipoferum* (log Cfu ml^{-1})				
	Control	**5 mM**	**10 mM**	**15 mM**	**20 mM**
Initial	9.75	9.77	9.78	9.75	9.76
1	9.98	10.83	10.97	10.99	10.97
2	9.94	10.76	10.93	10.96	10.94
3	8.92	10.20	10.05	10.10	10.08
4	7.90	9.14	10.00	10.08	10.06
5	6.89	8.76	9.80	10.03	10.00
6	4.73	7.58	9.60	10.01	10.00
SEd	0.002	0.001	0.002	0.003	0.003
CD (p=0.05)	0.004	0.002	0.004	0.005	0.006

TABLE 2. EFFECT OF DIFFERENT CONCENTRATION OF GLYCEROL ON THE SURVIVAL OF *Azospirillum lipoferum* UNDER LIQUID FORMULATIONS

Month	Population of *Azospirillum lipoferum* (log Cfu ml^{-1})				
	Control	**5 mM**	**10 mM**	**15 mM**	**20 mM**
Initial	9.75	9.77	9.78	9.75	9.76
1	9.98	10.42	10.94	10.96	10.93
2	9.84	9.96	10.88	10.90	10.87
3	8.92	9.04	10.03	10.07	10.04
4	7.90	8.87	10.01	10.05	10.03
5	6.89	7.64	9.99	10.00	9.97
6	4.73	6.58	9.97	10.00	9.46
SEd	0.004	0.003	0.004	0.002	0.002
CD(p=0.05)	0.007	0.005	0.007	0.004	0.003

TABLE 3. EFFECT OF DIFFERENT CONCENTRATION OF PVP ON THE SURVIVAL OF *Azospirillum lipoferum* UNDER LIQUID FORMULATIONS

Month	**Population of *Azospirillum lipoferum* (log Cfu ml^{-1})**				
	Control	**0.5 %**	**1.0 %**	**2.0 %**	**2.5 %**
Initial	9.75	9.77	9.78	9.75	9.76
1	9.98	10.03	10.24	10.91	10.86
2	9.84	9.96	10.63	10.85	10.73
3	8.92	9.24	9.96	10.01	9.82
4	7.90	8.64	8.96	9.99	8.94
5	6.89	7.94	8.64	9.97	8.84
6	4.73	6.32	7.21	9.96	8.21
SEd	0.001	0.002	0.002	0.003	0.001
CD(p=0.05)	0.002	0.003	0.003	0.005	0.002

EFFICACY STUDIES OF COST EFFECTIVE BIOFORMULATION OF CHITINOLYTIC BACTERIAL CONSORTIUM IN THE MANAGEMENT OF FOLIAR DISEASE INCIDENCE IN GROUNDNUT – AN INNOVATIVE APPROACH

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Abstract

Groundnut is the king of oil seed crop originated from Central Brazil. Nutritionally it contains high quality minerals and vitamins, with considerable amount of oil and proteins. Yield loss in groundnut is due to several factors viz., weeds, pest, bacteria, virus and fungal disease. The chitinolytic bacteria viz., Bacillus subtilis, Bacillus licheniformis, and Pseudomonas fluorescens which can produce chitinase enzyme were isolated from the rhizosphere soils of groundnut crop. Effect of chitinolytic bacterial culture filtrate was tested against foliar disease incidence in groundnut and from the field experiment the results reveled that, Among the chitinolytic bacterial culture filtrate tested individually and in combination, the novel bio formulated consortium of culture filtrate of Treatment, T_9 *- B. subtilis* (Bs_1) + *B. licheniformis* (Bl_3) + *P. fluorescens* (Pf_4) *@ 10 ml/Kg of seed recorded maximum control of foliar disease incidence at harvest stage at 12.20%. This was followed by dual inoculation* T_8 *recorded the disease incidence at 15.25% which was on par of* T_2 *- Carbendazim 50% WP as seed treatment @ 4g/Kg of seed. Hence it is concluded that the consortium of chitinolytic bacteria shows general trends towards the greater suppression of foliar disease incidence in groundnut and without chemical fertilizers, as demonstrated in this study better nutrient uptake, plant growth promotion and enhanced yield was observed.*

Keywords: *Chitinolytic Bacterial Consortium, Cercospora leaf spot.*

Inroduction

Groundnut (*Arachis hypogaea L.*) is a king of oil seed crop is popularly called as wonder nut and poor man's cashew nut. It is primarily utilized as seed as they are rich source of edible oils containing fat (40-50%), protein (20-50%) and carbohydrate (10-20%). Besides, several other important dietary components are also present in groundnut such as calcium, magnesium, phosphorus, zinc, iron, potassium, niacin, folacin, vitamin E, riboflavin and thiamine (Fabra *et al.*, 2010). Yield loss in groundnut is due to several factors like weeds, pest, insects, and diseases. Among the various diseases, *Cercospora* foliar disease incidence is the major factor in yield reduction of groundnut. The *Cercospora* foliar disease cause more than 55 per cent yield loss in groundnut under field condition. The use of many common pesticides, fungicides cause serious health problems. Chitinolytic microorganisms have been used as bio control agents for several crops with promising result. These chitinolytic microbes produced chitinase enzyme have received special attention due to their role in the bio control of fungal pathogens (Mathivanan *et al*., 1998). A variety of pathogenic microorganisms contain chitin coats which provide protection against external factors. Chitinase have been employed to breakdown these protective coats and weaken the defense system of several pathogenic microorganisms and insects (Hamid *et al.*,2013). This antagonistic advantage this research was designed and conducted to isolate and characterize the chitinolytic bacteria from groundnut rhizosphere soil. The present study isolates the chitinolytic

bacterial consortium against antagonistic effect of foliar *Cercospora* leaf spot disease incidence and to elucidate the reduced mycelial growth.

Materials and Methods

Isolation of Chitinolytic bacteria from groundnut rhizosphere soils

Chitinolytic bacteria were isolated from the rhizosphere soil samples collected from different groundnut growing areas of Tamil Nadu by serial dilution method on Nutrient agar medium, King's B medium for *Bacillus subtilis, Bacillus licheniformis* and *Pseudomonas fluorescens,* respectively by incubating at room temperature for 24 h. Colonies with characteristics of *Bacillus subtilis, Bacillus licheniformis* and *Pseudomonas fluorescens* were isolated individually and purified by streak plate method.

Preparation of Culture filtrates of different Chitinolytic bacteria

The effective chitinolytic bacterial isolates of Bacillus *subtilis, Bacillus licheniformis* and *Pseudomonas fluorescence* were inoculated into Erlenmeyer flasks, its contains 50 ml of Nutrient and 50 ml King's B broth respectively. The culture was incubated at 100 rpm rotaory shaker for 48 hrs. After incubation the culture was filtered through bacteriological filter under vacuum and the filtrates were used for the further studies.

Preparation of liquid formulation of Chitinolytic bacterial consortium

For the preparation of liquid formulation, the method suggested by Manikandan *et al.* (2010) was followed. The most effective isolate of Bacillus *subtilis* (Bs_1), *Bacillus licheniformis* (Bl_3) and *Pseudomonas fluorescens* (Pf_4) was inoculated individually into respective broth and incubated at room temperature (28± 2˚C). Further, the respective broths were added with glycerol at 2 per cent level. After incubation period, the formulation was assessed for adequate CFU following serial dilution plating technique and the formulation thus prepared.

Seed treatment with different chitinolytic bacteria

Seed of groundnut were surface sterilized with two per cent sodium hypochlorite for 30 seconds, rinsed in sterile distilled water and dried overnight. Ten ml of chitinolytic consortium based formulated inoculums was taken in a Petri dish. To this, 100 mg of carboxy methyl cellulose (CMC) was added as an adhesive material. Seeds were soaked in chitinolytic consortium suspension for 2 hours and air dried overnight in a sterile Petri dish.

Treatment Schedule:

T_1 : Control

T_2 : Carbendazim 50% WP as seed treatment @ 4g/kg

T_3 : *Bacillus subtilis* (Bs_1) @ 10 ml/kg of seed

T_4 : *Bacillus licheniformis* (Bl_3) @ 10 ml/kg of seed

T_5 : *Pseudomonas fluorescens* (Pf_4) @ 10 ml/kg of seed

T_6 : *Bacillus subtilis* (Bs_1) + *Bacillus licheniformis* (Bl_3) @ 10 ml/kg of seed

T_7 : *Bacillus licheniformis* (Bl_3) + *Pseudomonas fluorescens* (Pf_4) @ 10 ml/kg of seed

T_8 : *Pseudomonas fluorescens* (Pf_4) + *Bacillus subtilis* (Bs_1) @ 10 ml/kg of seed

T_9 : *Bacillus subtilis* (Bs_1) + *Bacillus licheniformis* (Bl_3) + *Pseudomonas fluorescens* (Pf_4) @ 10 ml/kg of seed

Experimental results

The data depicted in table-1 revealed that the seed treatment with chitinolytic bacteria either individually or as combination showed significant influence on the incidence of *Cercospora* leaf

spot of groundnut when compared to control. Among the various treatments the treatment (T_9 - *B. subtilis* (*Bs₁*) + *B. licheniformis* (*Bl₃*) + *P. fluorescens* (*Pf₄*) @ 10 ml/Kg of seed) recorded the minimum foliar disease incidence (11.70%) which was on par with that of treatment (T_2 - Carbendazim 50% WP as seed treatment @ 4g/Kg of seed)(13.50%). This was followed by the treatment with dual inoculation T_8 – *P. fluorescens* (Pf_4) + *B. subtilis* (Bs_1) @ 10 ml/Kg of seed (15.00%), T_7 - *B. licheniformis* (Bl_3) + *P. fluorescens* (Pf_4) @ 10 ml/Kg of seed (17.80%) and T_6 - *B. subtilis* (Bs_1) + *B. licheniformis* (Bl_3) @ 10 ml/Kg of seed (19.90%). The individual treatment T_3, T_4 and T_5 also recorded 23.90%, 23.00% and 21.70 per cent *Cercospora* leaf spot incidence, respectively. The maximum of 26.90 per cent was recorded in treatment T_1 (control).

Table – 1. Effect of seed treatment with chitinolytic bacterial consortium on foliar leaf spot incidence of groundnut.

Tr.No	Treatments	foliar leaf spot incidence (%)				Mean
		25 DAS	50 DAS	75 DAS	At harvest	
T_1	Control	23.10^h	25.40^g	28.70^f	30.20^f	26.90^h
T_2	Carbendazim 50%WP as seed treatment @4g/Kg of seed	7.70^a	11.50^a	15.20^a	19.55^a	13.50^b
T_3	*Bacillus subtilis* (Bs_1) @ 10 ml/Kg of seed	19.10^g	22.20^f	25.10^e	29.20^f	23.90^g
T_4	*Bacillus licheniformis* (Bl_3) @ 10 ml/Kg of seed	17.90^f	21.30^f	24.60^d	28.10^e	23.00^g
T_5	*Pseudomonas fluorescens* (Pf_4) @ 10 ml/Kg of seed	15.20^e	20.60^e	23.20^d	27.60^e	21.70^f
T_6	*B. subtilis* (Bs_1) + *B. licheniformis* (Bl_3) @ 10 ml/Kg of seed	13.78^d	18.20^d	21.90^d	25.70^d	19.90^e
T_7	*B. licheniformis* (Bl_3) + *P. fluorescens* (Pf_4) @ 10 ml/Kg of seed	11.68^c	17.90^c	19.40^c	22.40^c	17.80^d
T_8	*P. fluorescens* (Pf_4) + *B. subtilis* (Bs_1) @ 10 ml/Kg of seed	8.10^b	14.60^b	16.50^b	20.70^b	15.00^c
T_9	*B. subtilis* (Bs_1) + *B. licheniformis* (Bl_3) + *P. fluorescens* (Pf_4) @ 10 ml/Kg of seed	6.30^a	10.75^a	13.40^a	16.30^a	11.70^a

Means with same alphabets are statistically on par by Duncan's Multiple Range Test (DMRT) at 5% level

Conclusion

In most research to date, bio control agents were applied singly to combat a pathogen. But the results of the present study have proved that application with combination of bio control agents viz., *B. subtilis* (*Bs_1*) + *B. licheniformis* (*Bl_3*) + *P. fluorescens* (*Pf_4*) @ 10 ml/Kg of seed exhibited a general treand towards greater suppression of foliar disease in groundnut such as *Cercospora* leaf spot caused by *Cercospora personata.* In addition to disease control, better nutrient uptake, plant growth promotion and enhanced crop yield as observed in the present study adds another advantage over the use of fungicides in disease management strategies.

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PROTECTED CULTIVATION TECHNOLOGIES IN VEGETABLE CROPS

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Abstract

Agriculture and food systems have high risk of food and nutrition security due to rapid increasing human population and to protect environment from being exploited. Hence, new technologies must be adopted in agricultural system that meet increasing demand of food, reduction in malnutrition and are ecologically sustainable. Water management models in agriculture targets to reduce water wastage by determination of accurate water requirement by the crop and to increase the performance of water distribution by adoption of precise irrigation techniques. Under such conditions, greenhouse cultivation can play an important role in producing and sustaining higher yield and better quality of fruits than the open field cultivation. It is an improved agro technique being used worldwide to register 3-4 times increase in production. In general, profits are higher in off season vegetable crops provided climatic constraints are overcome by adopting protected cultivation technologies.

Keywords: *Climate, food system, nutrition, protected cultivation, quality, and yield.*

Introduction

World population growth in relation to UN organization will be expected nearly 8.3 and will be 10.9 billion in 2050. The rate of population expansion will lead to increase in food demand from 50% to 75% depending upon the area. Moreover, the worldwide climate conditions will also affect the productivity of food in various parts of the globe. Globally people suffered from deficiency of nutrition, which was about 821 million in 2017 approximately 10.9% of the world population. Orderly to support the global population, production of food kept stepped by increasing expansion and intensification of agriculture. Problem arises that how to increase sustainable production of food to supply as well as provide economic chances for rural and urban groups. The imbalanced application of traditional fertilizers, pesticides, weedicides, and fungicides has developed an alarming condition by rising pollution in edibles, atmosphere, and soil (Mohd *et al.*, 2021). Protected cultivation practices can be defined as a cropping technique wherein the micro environment surrounding the plant body is controlled partially/ fully as per plant need during their period of growth to maximize the yield and resources saving. Under this, crops are protected from abiotic (temperature, rain, wind, humidity etc.,) and biotic (diseases and insect-pests) stress. This helps in increased crop productivity and superior quality of produce can be obtained.Plants for efficient use of various inputs like water, fertilizer, seeds and plant protection chemicals can be well maintained in a green house.Percentage of germination of seeds is high in greenhouse.Greenhouses are suitable for automation of irrigation, application of other inputs and environmental control by using computer and artificial intelligence techniques.In open field in

India its average yield of tomato is 180.6 Q. per hectare which gets multiplied by three times under protected cultivation. The subsequent sections in this review will focus on the technological advancement in the field of agriculture leading to sustainable food, since these technologies will contribute in stabilizing food security throughout the globe without affecting the environment.

Effect of Protected Cultivation in Tomato

The experiment was conducted under naturally ventilated polyhouse and open field conditions, Kanwar, (2011) on five tomato genotypes including four hybrids (PH5, Shivalik, Jaya and Naveen 2000+) and one open field variety (PusaRohini) revealed that the performance of all tested tomato genotypes is far superior in the polyhouse, as compared to open field conditions, for all the considered characters. 'Shivalik' performed best with respect to yield characters followed by 'PusaRohini' under polyhouse conditions. However, in the open field, 'PusaRohini' showed the highest values, followed by 'Shivalik'. Cultivation of tomato under the polyhouse produced 136.12% more yield per ha and 188.93% more fruits per plant compared to open field cultivation.

Singh *et al*. (2015) on tomato seedlings (F1 hybrid tomato- Naveen) indeterminate were transplanted inside the PHs (poly houses) and SNHs (shade net houses) of insect pest infestation and quality of produce reported that stem diameters were recorded after 120 days of transplantation, i.e. in fully grown stage of the plants. Significantly more stem diameter ranging from 0.9 ± 0.2 to 1.2 ± 0.1 cm was observed in plants under PHs and 35% SNHs. Whereas, proliferated plant growth was recorded under 50 and 75% SNHs and diameter of the stems ranged from 0.6 ± 0.1 to 0.7 ± 0.2 cm only. Thus, as compared to open field (0.9 ± 0.3 cm) and PHs and SNHs plants, significantly less diameter of the tomato stems were observed under 50 and 75% SNHs. Chlorophyll a content ranged from 38.3 ± 7.2 to 76.6 ± 5.6 µg g-1 in leaves under the SNHs and this range was significantly more than the Chlorophyll a content in PHs, 35% SNHs and open field tomato plants, which was only 35.1 ± 6.6 to 36.0 ± 6.3 µg g^{-1} leaf. Similarly, chlorophyllb (Chl b) contents were also found significantly ($p \leq 0.05$) more under 50 and 75% shade net conditions, viz. under this reduced sunlight condition Chlorophyll b content ranged from 15.6 ± 3.6 to 28.5 ± 4.5 µg g^{-1} leaf, while in other protected and open field plants Chlorophyll b content was recorded 13.0 ± 5.3 to 14.2 ± 3.5 µg g^{-1} leaf.

The comparative economics of tomato cultivation under poly house and open field conditions conducted by Kumar *et al*. (2016) reveal that the cost of cultivation of tomato under poly houses was higher by Rs. 206816.90/acre as compared to open field conditions. At the same time, the net returns under poly houses were higher by Rs. 51097.54/ acre. Farmers realized 53.71 % higher yield of tomato under poly house as compared to open field conditions. The gross return, returns over variable cost and net return were also higher by 106.94 %, 160.70 % and 48.70 %, respectively in case of poly house as compared to open field conditions.

The experiments were conducted by Rosa and Cardoso, (2019) the two cultivations were carried out in spring/summer season (from October/2015 to March/2016 and the second from November/2016 to April/2017), Seven cultivars of tomatoes viz., the hybrids 'Serato', 'Tyson', and 'Predador', with undetermined type of growth; the open-pollinated 'Santa Clara' and 'Santa Cruz', with undetermined type of growth; and the hybrids 'Candieiro' and 'Apolo', with determined type of growth revealed that cultivar Predador showed greater individual fruit mass (> 180 g/fruit), similar to Serato (175 g/fruit). The cv. Serato showed the highest fruit yield (> 3 kg/plant), at least 1.2 kg/plant more than in the first cultivation. The cv. Predador showed the second highest productivity, with 2.8 kg/ plant, increasing 1.8 kg/plant compared with the previous cultivation. Regarding the cultivars with determined growth, Candieiro showed higher productivity

than Apolo, differing from the results obtained in the 1st cultivation. However, in both cultivars, the fruit production increased, in relation to the first, with yields of 1.7 (Apolo) and 2.0 kg/ plant (Candieiro) in the 2nd cultivation. These great increases in productivity were the result of the increase of number of fruits produced per plant is cv. Serato, in which dividing the fruit mass per plant by the individual mass of fruits, we have nine fruits/plant in the first cultivation (2015/ 2016), while in the second (2016/2017), this value was of 18.5 fruits/plant, more than double number of fruits.

An experiment was conducted at Hi-Tech Unit, by Singh *et a*l. (2019) evaluate the yield and quality traits of tomato hybrids under polyhouse condition revealed that hybrid Dev was performed extremely well under polyhouse condition with respect to yield parameters viz. yield per plant (5.50 kg) followed by Shahenshah (5.15 kg) and ArkaSamrat (4.32 kg). The hybrid TO-1057 gave the lowest marketable fruit yield (2.62 kg). The observation recorded for biochemical analysis showed that maximum titratable acidity (0.509%) followed by Emerald (0.402%) and Mahy-302 (0.396%). The highest mean value for ascorbic acid (17.77 mg/100 g) was recorded in ArkaSamrat which was highly significant and followed by Dev (15.38 mg/100 g) and Rajesh (13.28 mg/100 g). Highest mean value for lycopene content (5.80 mg/100 g) was recorded in ArkaSamrat which was highly significant and followed by Dev (4.21 mg/100 g) and Sarthi-044 (3.90 mg/100 g).

The experiment was conducted by Ganesan, (2020) the hybrid variety 'Vaishali' of tomato was grown under poly-greenhouses having different ventilation gaps and in an open field condition showed wide variations for the plant height (75.40-108.57 cm), node number (24.30-27.47), internodal length (3.09- 3.99 cm), flower number (75.67-218.13), average fruit weight (57.70-86.51 g), yield per plant (981.02-2145.21 g/plant) and plant dry matter production (34.15-74.60 g).

Stoleru*et al.* (2020) revealed that the effects of two fertilization types (chemical or organic) and two irrigation regimes (67% or 100% of evapotranspiration replenishment) on biometrical, biochemical, and yield parameters of three indeterminate cultivars of tomato grown in a greenhouse. The results showed that the effect of organic fertilization was better compared to chemical fertilization for antioxidant activity. The fruit number per plant for Siriana F_1 cultivar, chemically fertilized and watered with 300 $m^3 \cdot ha^{-1}$, showed a significant increase of 46.4% as compared to the organically fertilized plants irrigated with 200 $m^3 \cdot ha^{-1}$. The highest yields were obtained for cultivar HTP F_1, organically fertilized and irrigated according to the 100% evapotranspiration replenishment, followed by Siriana F_1 cv., chemically fertilized under the same irrigation regime. The best antioxidant activity was recorded for Inima de Bouand S cultivars as compared with the H cultivar.

Effect of Protected Cultivation in Capsicum

Two protected experiments were designed byZayed*et al*. (2013) to study the effect of organic fertilizer, soil solarization, and endomycorrhizae on yield and fruit quality of sweet pepper reported that the highest increase roots infection percentages when compared to other treatments, being 78% and 87% in the first and second seasons in respective order. The combined interaction between organic fertilizer, soil solarization, and VAM gave the highest significant increase in early and total yields (kg/plot) and total number of fruits/plots being 9.251 and 75.645 kg/plot and 529.3 fruits/plot, respectively. As the pepper cultivated in solarized soil supplemented with organic fertilizer gave 5.378 and 62.210 kg/plot and 460.375 fruits/plot respectively. However, the effect of combined interactions between organic fertilizer and VAM treatments showed that under these conditions, pepper gave 8.61 and 71.524 kg/plot early yield and total yield, respectively. In these

treatments, the number of fruits per plot reached 515.5fruits/plot. The pepper cultivated in soil neither supplied with organic fertilizer nor VAM gave 5.023 and 52.280 kg/plot and 389.313 fruits/plot, respectively.

The experiment was carried out by Rocha *et al*., (2018) on productive, physiological and phytotechnical characteristics of bell pepper under different irrigation strategies, in soil with mulch (polyethylene film, black on bottom, white on top) and without mulching observed that bell pepper production accumulated in three harvests ranged from 24 to 42.15 t ha^{-1} in mulched plot and from 17.72 to 24.58 t ha^{-1} in nonmulched plot. The quantity of bell pepper fruits was always higher in the presence of mulching. In mulching treatments, irrigation strategies with application of water depths of 50% and 75% of ETc and RDI conditions provided higher productivities, WUE and greater water savings, whereas water depths of 125 and 100% of ETc showed lower productivities. The Mass, diameter and length of fruits as well as the bell pepper peel thickness in relation to different harvest seasons (90, 120 and 150 DAT) presented higher average values in the first and second harvests values of (219.86g; 227.97g), (7.52 cm;7.47 cm), (14.23 cm;13.77 cm), (0.60 ;0.59) at 90 and 120 DAT respectively.

An experiment was conducted by Bijeta*et al*. (2018) on the effect of growing media and plant spacing on growth and yield of capsicum cv. Orobelle in naturally ventilated polyhouse result showed that the minimum values for Days to 50 per cent flowering (41.89) and days to marketable maturity (71.56), whereas, maximum values for harvest duration (85.67), and plant height (154.46 cm) were recorded the media consisting of Soil + Cocopeat + Vermicompost + FYM (2:1:0.5:0.5) proved to be statistically superior over rest of the growing media for almost all the aspects under investigation. Plant spacing had a significant influence on growth characters of capsicum during both the years. Capsicum raised at 45 x 60 cm (S_3) obtained minimum days to 50 per cent flowering, minimum (42.29) days to marketable maturity (71.50), taller plants (151.66) and maximum harvest duration (82.71), which was statistically at par with 45 x 45 cm (S_2). Taller plants might be due to competition of light under S_1 (45 x 30 cm) with closer plant to plant space for want of light.

The yield per plant increased significantly with the incorporation of cocopeat and vermicompost together in M_3 media. The media consisting of cocopeat, vermicompost and FYM which was followed by M_4. M_3(Soil+Cocopeat+vermicompost (2:1:1) recorded the highest number of fruits per plant (14.86) and fruit breadth (9.80 cm). The media M_4(Soil+Cocopeat+vermicompost+ FYM (2:1:0.5:0.5) recorded the maximum fruit length (10.25 cm), average fruit weight (192.91 g), fruit yield (2.81 kg/plant). Wider spacing produced significantly a greater number of fruits per plant (14.39), fruit length (9.84 cm), fruit breadth (9.48 cm), average fruit weight (227.00 g), fruit yield (3.28 kg/plant) during both the years. The wider spacing of 45 x 60 cm^2 leads to more growing area and better competition among plants and subsequently better growth which in turn had a positive effect on yield attributes.

On the effect of growing media and plant spacing on growth and yield of capsicum cv. Orobelle in naturally ventilated polyhouse revealed that the maximum B: C ratio of 2.23:1 was obtained with combination M_4S_2 (Soil + Cocopeat + Vermicompost + FYM (2:1:0.5:0.5) with plant spacing 45 x 45 cm), which was very close with the treatment combination M_4S_3 (Soil + Cocopeat + Vermicompost + FYM (2:1:0.5:0.5) with plant spacing 45 x 60 cm) which obtained the B: C ratio of 2.03:1, whereas, minimum B: C ratio (1.25:1) was resulted from the treatment M_1S_1 (Soil + Sand + FYM (2:1:1) with plant spacing 45 x 30) cm. The result of this investigation showed that the growing media Soil + Cocopeat + Vermicompost + FYM (2:1:0.5:0.5) at a plant spacing 45 x 60

cm2 and 45 x 45 cm^2 gave highest growth and yield characters of capsicum cv. OrobelleBijeta*et al*. (2018).

The study was conducted by Kumar *et al*. (2018) for capsicum raised under naturally ventilated polyhouse from the study of three years it was observed that the yield of capsicum per thousand m^2 was 110 quintals which was sold at the rate of Cost 4000 per quintal in market. Thus, the gross return from capsicum cultivation under protected condition was worked out to Cost 440000 per thousand m^2. It is depicted in that the highest net return per thousand m^2 was realized when the cultivation of capsicum was done with 75% subsidy which was worked out to Cost 201709.82. Whereas it was estimated to Cost 183772.12 when the cultivation of capsicum was done with 65% subsidy.

At 30 DAT, plant height and no. of leaves were observed maximum 73.25 cm and 20 in T_3 (trickle irrigation with 80 % of ETc with mulch) treatment, which is significantly good than rest five irrigation treatments. The minimum height of plant and no. of leaves, 65.05 cm, & 16 were recorded in T_5 treatment. Similar trends were noticed at 60 DAT, 90 DAT, and 120 DAT and at the 150 DAT. At 60 DAT, among the six irrigation treatments, maximum plant per flower 9.21 in T_3. At last harvesting (150 DAT), among the six different irrigation treatments, cumulative per plant fruit count were observed highest 11.31 in T_3 treatment, which is significantly good over in the all-rest treatments. The highest percent fruit sets (51.07 %) were recorded in treatment (T_3) Bhakar*et al*. (2019).

This study aims to evaluate the effect of supplemental irrigation levels on vegetative parameters of bell pepper grown in open field and under shade mesh, carried out by Padron *et al*. (2015) on irrigation treatments consisted in 0.25, 0.50, 0.75 and 1.0 rate of crop evapotranspiration and the control (no-irrigation) revealed that the open-field plots, $I_{0.50}$ and $I_{0.75}$, had a greater development during the crop cycle and under shade, $I_{1.0}$ and $I_{0.75}$. In I_0 and $I_{1.0}$open field plots,a less leaf area index was observed and under shade, I_0 and $I_{0.25}$. The leaf area index of $I_{0.50}$ was similar in both environments. It could be inferred that the leaf area index was affected by the deficit and excess water. Generally, excess damp has an adverse effect on treatment with 50% shading, possibly optimal humidity is 50% of ET.

An experiment was conducted by Mohamed *et al*. (2015) during the autumn seasons of 2010/2011 and 2011/2012 to study the economic considerations of using different types of organic manure on sweet pepper yield under protected cultivation (Vermicompost, compost and Cattle manure at the rates of 2, 4 and 6% (1.8, 3.6 and 5.4 m^3 /plastic house of 540m^2) resulted that the vermicompost recorded the highest values of early and total yield in both seasons while there is no significant difference between compost and cattle manure applications. The data indicated that the treatment of vermicompost at the rate 4% recorded the highest values of early and total yield of sweet pepper followed by vermicompost at the rate 6 % while the lowest results gave by compost at 2%.

Conclusion

The protected cultivation of vegetable crops is an advantageous grown by this method is safe to consume due to less use of chemical, this technique also provides congenial environment to off season cultivation as well as high & quality production. Therefore, increasing demand of vegetable for growing population can be fulfilled by this technology.

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INFLUENCE OF ORGANIC MULCHES AND BIOSTIMULANTS ON VEGETATIVE PARAMETERS AND NUTRIENT UPTAKE OF TUBEROSE (*polianthes tuberosa* L.) CV. PRAJWAL

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Abstract

Tuberose (Polianthes tuberosa L.) is an important commercial flower in international market. An experiment entitled "Influence of organic mulches and biostimulants on vegetative parameters and plant nutrient uptake of tuberose of tuberose (Polianthes tuberosa L.) cv. Prajwal" was carried out in the Rajendhirapattinam village, Virudhachalam, Tamil Nadu during the priod 2019 to 2021. This experiment was carried out by following the principles of randomized block design (RBD) with three replications comprising ten treatments. The experiment was conducted by using different organic mulch materials viz., paddy straw mulch @ 10 t ha^{-1}, sugarcane trash mulch @ 5 t ha^{-1}, sawdust mulch @ 20 t ha^{-1} along with different biostimulants viz., panchagavya @ 3%, seaweed extract @ 3% and fish amino acid @ 3%. The various treatments significantly influenced the vegetative parameters and plant nutrient uptake of tuberose. Among the different treatments, T_3 (paddy straw mulch @ 10 t ha^{-1} + fish amino acid @ 3%) was found to be more effective for better performance of the vegetative parameters viz., plant height (22.56 cm), number of leaves plant^{-1} (28.69), plant spread (25.18 cm), leaf area (43.76 cm^2) and the plant nutrient uptake was also markedly increased.

Key words: *Tuberose, Paddy straw, Sugarcane trash, Saw dust, Panchagavya, Seaweed extract, Fish amino acid*

Introduction

Tuberose (*Polianthes tuberosa* L.) is an important flower crop grown in India mainly for its beautiful and fragrant cut flowers as well as loose flowers, belongs to family amaryllidaceae and is commonly known as rajnigandha or nishigandha. It is one of the most important commercial flowers among the bulbous ornamentals. It blooms profusely throughout year and it is considered as a potential money spinner with immense export prospects especially to gulf countries. They are valued much by the aesthetic world for their beauty and fragrance. It has long been cherished for the aromatic oils extracted from its fragrant flowers. There is high demand for tuberose concrete and absolute in the international markets which fetch a very good price. Tuberose can successfully be grown in pots, borders, beds and commercially cultivated for its various uses, as for making artistic garlands, floral ornaments, and bouquets.

Mulching is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development, and efficient crop production. It increases the soil temperature and moisture, keeps growth of the weeds considerably down besides improving the chemical and physical properties of the soil thereby improving the productivity of the crop. Organic mulches are those natural origin materials which can decompose naturally, like agricultural wastes which are used as mulch, such as bark chips, grass clippings, paddy straw, sugarcane trash, compost, and sawdust, etc. This organic mulch layer reflects the maximum sunlight or else sunlight heats the soil. It maintains the optimum soil temperature. The rate of evaporation from the soil surface was restricted due to the avoiding of direct entry of solar radiation. So, its application is beneficial in hot and dry climates.

Mulch layer also restricts the weed growth because if soil is covered with mulch layer than light is not reached at soil surface. It also protects soil surface to erosion from the high-speed wind and surface runoff. Organic mulches are also improved the soil characteristics. These mulches are slowly decomposed, and they increase organic content in the soil which helps to keep the soil loose. These organic contents become food for the useful earthworms and other micro-organisms available in the soil. The organic mulches also improve the organic carbon in the soil. It facilitates the better root penetration and root development and extraction of nutrients from a deeper layer of the soil. It improves root growth of the crop, increases the infiltration of water, and water retention capacity of the soil. The organic mulches attract most of the soil beneficial micro-flora which in turn act on the degradable wastes and aids in the release of plant nutrients.

Biostimulants are products that reduce the need for fertilizers and increase the plant growth, resistance to water and abiotic stresses. In small concentrations, these substances are efficient, favoring the good performance of the plants vital process and allowing high yields and good quality products. Keeping in view of above said facts, the present trial was conducted to study the influence of organic mulches and biostimulants on vegetative parameters and plant nutrient uptake of tuberose (*Polianthes tuberosa* L.) cv. Prajwal.

Materials and Methods

The present investigation entitled "Influence of organic mulches and biostimulants on vegetative parameters and plant nutrient uptake of tuberose (*Polianthes tuberosa* L.) cv. Prajwal" was carried out in the Rajendhirapattinam village, virudhachalam, Tamil Nadu during the year 2019 to 2021. Healthy and matured uniform size bulbs were procured and stored temporarily in a cool shady place and utilized for the present study. This experiment was carried out by following the principles of randomized block design (RBD) with three replications comprising ten treatments. The experiment was conducted by using different organic mulch materials *viz*., paddy straw mulch @ 10 t ha^{-1}, sugarcane trash mulch @ 5 t ha^{-1}, sawdust mulch @ 20 t ha^{-1} along with different biostimulants *viz*., panchagavya @ 3%, seaweed extract @ 3% and fish amino acid @ 3%.

After completion of planting, three types of organic mulches were applied as per the treatments. The prepared solutions of biostimulants were applied three times as foliar spray at 30 days interval from 45 days after planting as per the treatments in individual plots. Spraying was done with hollow cone pore size nozzle. Percentage solutions were prepared by mixing 3 ml solute in 100 ml solvent (water). Five plants were randomly selected from each plot and tagged for recording observations on various vegetative parameters *viz*., plant height, number of leaves $plant^{-1}$, plant spread and leaf area. The experimental data were statistically analyzed by analysis of variance for Randomized Block Design for significant test as described by Panse and Sukhatme (1985).

Results and Discussion

Vegetative parameters

Vegetative parameters are those primary parameters which include plant height (cm), plant spread (cm^2), number of leaves $plant^{-1}$, leaf area (cm^2), and these characters influence the yield parameters greatly.

The maximum plant height (22.56 cm) was obtained in T_3 with the application of paddy straw mulch @ 10 t ha^{-1} along with foliar application of fish amino acid @ 3% which was found to be significantly higher over all other treatments and the lowest value was recorded in control (16.03 cm). Increased plant height might be due to the combined effect of organic mulches and biostimulants on plants. Mulching helps to reduce the soil temperature and conserve soil moisture regime as well as it maintains the physicochemical properties. It helps to reduce leaching of manures and fertilizers. Fish Amino Acid, the easy transfer of nutrients to plant through foliar spray could have created the stimuli in the plant system which in turn increased the production of growth regulators in cell system resulting in higher plant height. Quick absorption and assimilate of more nitrogen, phosphorus, potassium, and micronutrients present in fish amino acid through foliar spray would have improved the metabolic activity and cell division resulting in increased plant height. Similar results were observed by Singh and Kavitha (2005) in rose and Solaiman *et al*. (2008) in China aster.

The maximum number of leaves $plant^{-1}$ (28.69) was obtained in T_3 with the application of paddy straw mulch @ 10 t ha^{-1} along with foliar application of fish amino acid @ 3% which was found to be significantly higher over all other treatments. This was followed by the application of sugarcane trash mulch @ 5 t ha^{-1} along with fish amino acid @ 3% (T_6) with the value of 27.98 and the lowest value was recorded in control (21.93). This was because of paddy straw mulch over the weed population which reduced the competition greatly and helped to maintain soil moisture content. Along with this spraying of fish amino acid enhanced the beneficial microbial activity and it increased the nutrient assimilation and sink in plants. The increase in the number of leaves $plant^{-1}$ with organic nutrient application might be attributed to synthesis of tryptophan which promotes intensity of auxins leading to more cell division and cell elongation, meristematic activity of the tissue and expansion of cells, enhanced the availability of macronutrients. Similar results were observed by Hong *et al*. (2001) in lilies and Barman *et al*. (2015) in tuberose.

The mean data observed with maximum plant spread (25.18 cm) and leaf area (43.76 cm^2) was with paddy straw mulch @ 10 t ha^{-1} along with fish amino acid @ 3% (T_3) and the lowest value was recorded in control (17.56 and 33.25 cm respectively). The effect of paddy straw mulch reduces the weed competition which in return increased nutrient uptake and amino acids present in fish amino acid acts as precursors of growth hormones in promoting growth via improved photosynthesis which enhanced the vegetative growth profusely. The maximum plant spread might be due to fish amino acid which favors storage of more carbohydrates through photosynthesis resulted with wider plants. Similar results were observed by Barman *et al*. (2005) in gladiolus, Amin *et al.* (2015) in tuberose and Sivasankar *et al*. (2021) in marigold.

Plant nutrient uptake

The major nutrients *viz.*, nitrogen, phosphorus and potassium play a vital role in the plant physiology and growth and these elements cannot be replaced by any other. Nitrogen is a major constituent of proteins, enzymes, chlorophyll, and nucleic acid. It is involved in the cell division, cell enlargement and in respiration. Phosphorus plays a major role in the development of

reproductive parts and root formation. Potassium plays a major role in activating many enzymes to induce flowering, fruit set, and in translocation of carbohydrates. In the present study, the maximum uptake of nitrogen (3.12%), phosphorus (1.02%) and potassium (4.93%) were observed in the treatment which received T_3 (paddy straw mulch @ 10 t ha^{-1} along with fish amino acid @ 3%) and the lowest nutrient uptake was recorded in control (2.07, 0.61 and 3.79% respectively).

This might be due to mulching leads to better moisture and thermal regimes that enhances root growth which ultimately leads to increase in the potential for efficient nutrient uptake and mulching suppress the weed growth which leads to less competition between the weeds and crop for nutrient and moisture which may have led to better nutrient use efficiency by the crop ultimately enhance the yield (Kumar and Dey, 2011). Fish amino acid is a chief source of nitrogen for the plants and soil microorganisms. Since the nutrient content of the fish amino acid is slowly released, it provides continuous supply of nutrient to the plant in the minimal amount. These observations and findings in the present investigation are in conformity with those reported earlier by Priyanka *et al*. (2019) in green gram.

Conclusion

Based on the findings of the present investigation, it is concluded that the application of paddy straw mulch @ 10 t ha^{-1} + fish amino acid @ 3%) was found to be more effective for better performance of the vegetative parameters of tuberose (*Polianthes tuberosa* L.) cv. Prajwal under open field condition. The plant nutrient uptake was also markedly increased by this treatment.

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Table 1 - Influence of organic mulches and biostimulants on vegetative parameters in tuberose (*Polianthes tuberosa* L.) cv. Prajwal

Treatments	Plant height (cm)	Number of leaves plant^{-1}	plant spread (cm)	leaf area (cm^2)
T_1- Paddy straw mulch @ 10 t ha^{-1} + Panchagavya 3%	21.22	27.25	23.61	41.59
T_2- Paddy straw mulch @ 10 t ha^{-1} + Seaweed extract 3 %	19.21	25.14	21.38	38.56
T_3- Paddy straw mulch @ 10 t ha^{-1} + Fish amino acid 3%	22.56	28.69	25.18	43.76
T_4- Sugarcane trash mulch @ 5 t ha^{-1} + Panchagavya 3 %	20.54	26.54	22.83	40.51
T_5- Sugarcane trash mulch @ 5 t ha^{-1} + Seaweed extract 3%	17.94	23.84	19.81	36.39
T_6- Sugarcane trash mulch @ 5 t ha^{-1} + Fish amino acid 3%	21.89	27.98	24.40	42.67
T_7-Saw dust mulch @ 20 t ha^{-1} + Panchagavya 3%	18.52	24.42	20.59	37.47
T_8- Saw dust mulch @ 20 t ha^{-1} + Seaweed extract 3 %	17.25	23.15	19.02	35.28
T_9-Saw dust mulch @ 20 t ha^{-1} + Fish amino acid 3%	19.87	25.85	22.04	39.42
T_{10}- Control	16.03	21.93	17.56	33.25
S.Ed	0.32	0.34	0.38	0.53
CD (P = 0.05)	0.64	0.68	0.76	1.06

Table 2 -Influence of organic mulches and biostimulantson plant nutrient uptake (Per cent) in tuberose (*Polianthes tuberosa* L.) cv. Prajwal

Treatments	N (%)	P (%)	K (%)
T_1- Paddy straw mulch @ 10 t ha^{-1} + Panchagavya 3%	2.89	0.93	4.67
T_2- Paddy straw mulch @ 10 t ha^{-1} + Seaweed extract 3 %	2.62	0.83	4.35
T_3- Paddy straw mulch @ 10 t ha^{-1} + Fish amino acid 3%	3.12	1.02	4.93
T_4- Sugarcane trash mulch @ 5 t ha^{-1} + Panchagavya 3 %	2.79	0.89	4.54
T_5- Sugarcane trash mulch @ 5 t ha^{-1} + Seaweed extract 3%	2.40	0.69	4.09
T_6- Sugarcane trash mulch @ 5 t ha^{-1} + Fish amino acid 3%	3.01	0.98	4.80
T_7-Saw dust mulch @ 20 t ha^{-1} + Panchagavya 3%	2.51	0.79	4.23
T_8- Saw dust mulch @ 20 t ha^{-1} + Seaweed extract 3 %	2.28	0.69	3.97
T_9-Saw dust mulch @ 20 t ha^{-1} + Fish amino acid 3%	2.68	0.85	4.42
T_{10}- Control	2.07	0.61	3.79
S.Ed	0.05	0.02	0.06
CD (P = 0.05)	0.10	0.04	0.12

STUDIES ON CORRELATION AND PATH ANALYSIS IN RICE GENOTYPES FOR GRAIN YIELD UNDER INDUCED DROUGHT CONDITION

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Abstract

Rice is an important cereal crop, grown globally and it is consumed by most of the Asian countries. The prevailing climatic change is a major threat to abiotic stress agriculture for increasing the rice production and productivity. The present investigation was carried out to formulate the selection indices under drought stress on 30 rice genotypes and aimed to study the information on interrelationships of various traits associated with grain yield. The rice genotypes were raised in plots laid out in randomized block design with three replications. The stress treatment was then initiated by confining irrigation, four weeks after transplanting. The treatment was maintained until the plants shows rigorous stress symptoms such as severe rolling of leaves and drying of tips, when these symptoms appear, the field is flushed with water until the moisture content of gravimetric soil reaches 12%. Subsequently the observations were made under drought conditions on Nine economically important characters viz., Days to 50 % flowering, Plant height at maturity, Number of tillers per plant, Number of productive tillers per plant, Panicle length, Number of grains per panicle, 100 Seed weight, Spikelet fertility and Grain yield per plant.

The characters, number of productive tillers per plant, Panicle length, and number of grains per panicle, hundred seed weight and Spikelet fertility showed significant positive correlation with grain yield per plant. Among the nine yield component traits Days to 50 % flowering, Plant height at maturity, number of productive tillers per plant, Panicle length, 100 Grain weight and Spikelet fertility were recorded positive direct effect on Grain yield per plant.

Key words: Drought, Correlation, Grain yield.

Introduction

Rice (*Oryza sativa* L. $2n = 2x = 24$), an edible starchy grain belongs the genus *Oryza* is thought to have originated about 14 million years ago. Rice crop production is challenged by both biotic and abiotic stresses. Rice, being a high-water requiring crop gets affected by drought. Drought is exacerbated by climate change and growing anthropogenic pressures, and it is threatening the region's water security (Patrick, 2017). Drought stress causes remarkable damage during reproductive stagewhich in turn reduces the plant yield. Developing rice varieties that are both productive and drought tolerant is of greater urgency. In this context the present study focused on studying the yield and yield related components through correlation. Thereby direct selection for yield is not effective as yield is a complex and quantitatively inherited character with low heritability. Therefore, indirect selection could be made for the component characters contributing to yield through character association as it provides information about the characters that are correlated with each other in improving yield.

Materials and Methods

To investigate the effect of drought stress 30rice genotypes were collected (Table 1). The field experiments were conducted at reproductive stage under drought environmental conditions at the experimental farm of Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, during kharif season of 2018-2020. The experiment was laid out in randomized block design with three replications. Seeds of 30 genotypes were sown in raised nursery bed during July, 2019 to October, 2019.

Irrigation was initially applied at 3-4 days' interval and the soil in the stress plots were kept saturated up to 25 days after germination or 4 weeks after transplanting. The stress treatment was then initiated by arresting irrigation. As the soil dries, water content of gravimetric soil was monitored at an interval of 5-days from soil samples collected from the depth of 15-30 cm at three different locations in each replication. In each season, the drought stress treatment was maintained until the plants shows severe stress symptoms such as severe rolling of leaves and drying of tips. When these symptoms appear, the field is flushed with water until the moisture content of gravimetric soil reaches 12%.

To study the association between variables and grain yield, the phenotypic and genotypic correlation co-efficient were worked out following Aljibouri *et al.* (1958)

The direct and indirect effect of yield attributing traits on fruit yield were calculated through path co-efficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

Observations were recorded on 30 rice genotypes for 9 characters viz. Days to 50 % flowering, Plant height at maturity, Number of tillers per plant, Number of productive tillers per plant, Panicle length, Number of grains per panicle, 100 Seed weight, Spikelet fertility and Grain yield per plant.

Results and Discussion

In the present investigation, days to first flowering had non-significant negative correlation with Panicle length at phenotypic level. The characters number of productive tillers per plant and 100 seed weight had significant positive correlation with grain yield per plant at both genotypic and phenotypic level of correlation, whereas the Plant height recorded a negative and significant association with total yield. Number of grains per panicle recorded a positive and significant association with grain yield per plant. The Genotypic and Phenotypic correlation analysis for nine characters were presented in the Table 2.

Among the nine yield component traits, Days to 50 % flowering, Plant height at maturity, Number of productive tillers per plant, Panicle length, 100 Grain weight and Spikelet fertility were recorded positive direct effect on Grain yield per plant. The two traits Number of tillers per plant and Number of grains per panicle showed negative direct effect on grain yield. The estimated residual effect was 0.359151(Table 3). High positive direct effect on grain yield per plant was registered by Number of productive tillers per plant. This result goes with the findings of Amudha *et al.* (2006), Javed Iqbal Wattoo *et al.* (2010), Satheesh Kumar and Saravanan (2013) and Kalyan *et al.* (2017). In addition, days to 50 % flowering had positive indirect effect on Plant height at maturity, Number of tillers per plant and Number of grains per panicle. Likewise, Plant height at maturity had positive indirect effect on grain yield per plant through days to 50 % flowering, Number of tillers per plant and Number of grains per panicle. Hundred Seed weight had positive indirect effect on grain yield per plant through Number of productive tillers per plant, Panicle length and Spikelet fertility. The cause and effect of relationship indicated maximum direct effect on grain

yield per plant was through number of productive tillers per plant, followed by hundredgrain weight and Plant height at maturity. This suggests that these characters deserve greater weightage while formulating selection indices in rice breeding.

Table 1. Germplasm used

S.No	Genotypes	Code	Source
1.	AVT 3406	G1	ICAR-Indian Institute of Rice Research, Hyderabad
2.	AVT 3407	G2	ICAR-Indian Institute of Rice Research, Hyderabad
3.	AVT 1-AL 3401	G3	ICAR-Indian Institute of Rice Research, Hyderabad
4.	AVT 1-AL 3404	G4	ICAR-Indian Institute of Rice Research, Hyderabad
5.	AVT 1-AL 3405	G5	ICAR-Indian Institute of Rice Research, Hyderabad
6.	AVT 1-AL & ISTVT 3402	G6	ICAR-Indian Institute of Rice Research, Hyderabad
7.	AVT 1-AL & ISTVT 3403	G7	ICAR-Indian Institute of Rice Research, Hyderabad
8.	IVT 3503	G8	ICAR-Indian Institute of Rice Research, Hyderabad
9.	IVT 3505	G9	ICAR-Indian Institute of Rice Research, Hyderabad
10.	IVT 3506	G10	ICAR-Indian Institute of Rice Research, Hyderabad
11.	IVT 3507	G11	ICAR-Indian Institute of Rice Research, Hyderabad
12.	IVT 3510	G12	ICAR-Indian Institute of Rice Research, Hyderabad
13.	IVT 3511	G13	ICAR-Indian Institute of Rice Research, Hyderabad
14.	IVT 3513	G14	ICAR-Indian Institute of Rice Research, Hyderabad
15.	IVT 3514	G15	ICAR-Indian Institute of Rice Research, Hyderabad
16.	IVT 3515	G16	ICAR-Indian Institute of Rice Research, Hyderabad
17.	IVT 3516	G17	ICAR-Indian Institute of Rice Research, Hyderabad

18.	IVT 3517	G18	ICAR-Indian Institute of Rice Research, Hyderabad
19.	IVT 3518	G19	ICAR-Indian Institute of Rice Research, Hyderabad
20.	IVT 3519	G20	ICAR-Indian Institute of Rice Research, Hyderabad
21.	IVT 3520	G21	ICAR-Indian Institute of Rice Research, Hyderabad
22.	IVT 3521	G22	ICAR-Indian Institute of Rice Research, Hyderabad
23.	IVT 3523	G23	ICAR-Indian Institute of Rice Research, Hyderabad
24.	IVT - AL & ISTVT3501	G24	ICAR-Indian Institute of Rice Research, Hyderabad
25.	IVT - AL & ISTVT 3504	G25	ICAR-Indian Institute of Rice Research, Hyderabad
26.	IVT - AL & ISTVT 3508	G26	ICAR-Indian Institute of Rice Research, Hyderabad
27.	IVT - AL & ISTVT 3509	G27	ICAR-Indian Institute of Rice Research, Hyderabad
28.	IVT - AL & ISTVT 3522	G28	ICAR-Indian Institute of Rice Research, Hyderabad
29.	KR-15003	G29	Directorate of Rice Development, Patna
30.	KR-15005	G30	Directorate of Rice Development, Patna

Table 2.Genotypic and Phenotypic correlation analysis for nine characters of rice

Genotypic and Phenotypic correlation		ays to 50 % owering	Plant height	Number of tillers per plant	Number of productive tillers per plant	Panicle length	Number of grains per panicle	Hundred Seed weight	Spikelet fertility	Grain yield per plant
Days to fifty % flowering	G	1.000	0.528**	-0.640**	-0.681**	-0.433*	-0.682**	-0.734**	-0.645**	0.541**
	P	1.000	0.422*	-0.490**	-0.592**	-0.330	-0.602**	-0.592**	-0.500**	-0.451*
Plant height	G		1.000	-0.793**	-0.816**	-0.660**	-0.757**	-0.765**	-0.741**	-0.613**
	P		1.000	-0.575**	-0.679**	-0.485**	-0.635**	-0.537**	-0.537**	-0.482**

Number of tillers per plant	G			1.000	0.985**	0.599**	0.834**	0.803**	0.811**	0.797**
	P			1.000	0.871**	0.465**	0.709**	0.625**	0.582**	0.616**
Number of productive tillers per plant	G				1.000	0.670**	0.878**	0.871**	0.861**	0.852**
	P				1.000	0.591**	0.849**	0.721**	0.762**	0.790**
Panicle length	G					1.000	0.726**	0.595**	0.765**	0.727**
	P					1.000	0.658**	0.476**	0.660**	0.640**
Number of grains per panicle	G						1.000	0.803**	0.866**	0.775**
	P						1.000	0.672**	0.767**	0.720**
Hundred Seed weight	G							1.000	0.730**	0.817**
	P							1.000	0.557**	0.627**
Spikelet fertility	G								1.000	0.777**
	P								1.000	0.658**
Grain yield per plant	G									1.000
	P									1.000

** Significance at 1 % level, * Significance at 5 % level

G – Genotypic correlation co-efficient, P – Phenotypic correlation co-efficient

Table 3. Direct and Indirect effects of various characters on Grain yield per plant

EFFECT OF CHARACTER	VIA CHARACTER								
	Days to50 %Flowering	Plant height at maturity	Number of tillers per plant	Number of productive tillers per plant	Panicle length	Number of grains per panicle	Hundred Seed weight	Spikelet fertility	Grain yield per plant
Days to 50 % flowering	**0.227**	0.245	0.115	-0.599	-0.139	0.043	-0.373	-0.061	0.541
Plant height at maturity	0.120	**0.464**	0.143	-0.717	-0.211	0.048	-0.389	-0.070	-0.613
Number of tillers per plant	-0.145	-0.368	**-0.180**	0.866	0.192	-0.053	0.408	0.077	0.797

Number of productive tillers per plant	-0.154	-0.379	-0.178	**0.879**	0.215	-0.056	0.443	0.082	0.852
Panicle length	-0.098	-0.306	-0.108	0.589	**0.320**	-0.046	0.302	0.073	0.727
Number of grains per panicle	-0.155	-0.352	-0.150	0.772	0.233	**-0.063**	0.409	0.082	0.775
Hundred Seed weight	-0.166	-0.355	-0.145	0.766	0.190	-0.051	**0.509**	0.069	0.817
Spikelet fertility	-0.146	-0.344	-0.146	0.757	0.245	-0.055	0.371	**0.095**	0.777

Residual effect=0.359151 Boldvalues–DirecteffectUnbold values – Indirecteffect

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EFFECT OF MULCHING AND ORGANIC NUTRIENTS ON CERTAIN GROWTH AND PHYSIOLOGICAL CHARACTERS OF BOTTLE GOURD (*Lagenaria siceraria*) cv. PUNJAB KOMAL

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Abstract

A field experiment on "Effect of mulching and organic nutrients on certain growth and physiological characters of bottle gourd [Lagenaria siceraria (Molina) Standl.]" cv. Punjab Komal was carried out in the farmer's field, Kothamangalam south, Alangudi Taluk, Pudukkottai District, Tamilnadu during 2020 – 2022.The experiment was laid in Randomized Block Design (RBD) with thirteen treatments and replicated thrice.The treatment consists (T_1) silver - black plastic mulch sheet (25µm) thickness, (T_2) silver - black plastic mulch sheet (25 µm) thickness + panchagavya @ 3 %, (T_3) silver - black plastic mulch sheet (25 µm) thickness + fish amino acid @1 %, (T_4) Silver - black plastic mulch sheet (25 µm) thickness + vermiwash @ 5 %, (T_5) paddy straw mulch (8 cm) thickness, (T_6) paddy straw mulch (8 cm) thickness + panchagavya @ 3 %, (T_7) paddy straw mulch (8 cm) thickness + fish amino acid @ 1 %, (T_8) paddy straw mulch (8 cm) thickness+ vermiwash @ 5 %, (T_9) saw dust mulch (4 cm) thickness , (T_{10}) saw dust mulch (4 cm) thickness + panchagavya @ 3 %, (T_{11}) saw dust mulch (4 cm) thickness + fish amino acid @ 1 %, (T_{12}) saw dust mulch (4 cm) thickness + vermiwash @ 5 % and (T_{13}) Control. The result of experiment revealed that among the various treatment, maximum values in growth and physiological characters viz vine length, number of leaves, total chlorophyll content, and dry matter production were recorded with (T_4) silver - black plastic mulch sheet (25 µm) thickness + vermiwash @ 5 % . It was followed by (T_2) silver - black plastic mulch sheet (25 µm) thickness + panchagavya @ 3 %.

Key words: *Bottle gourd, mulching, vermiwash and panchagavya*

Introduction

India share (14.78 per cent) generation of squashes, pumpkin and gourd to universe absolute creation and stands at second position after China (22.83 per cent) (Anonymous, 2016). In India, it was cultivated in 192 thousand hectares with a production of 3143 thousand ton. It is grown in the area of 5.20 thousand hectares with annual production of 103.24 thousand ton in Tamil Nadu. The plants of cucurbitaceae family provide the major contribution for economically important domesticated species and are cultivated for medicinal and nutrition value. Bottle gourd [*Lagenaria siceraria* (Molina) Standl.] is a valuable member of the cucurbitaceae family, with chromosome number of 2n = 22, originate from South Africa. It is a tropical plant which is currently cultivated all around world. Bihar, Uttar Pradesh, Chhattisgarh, Punjab, Madhya Pradesh, Andhra Pradesh, and Tripura are the major bottle gourd growing states in India. It was widely grown in India, Sri Lanka, Indonesia, Malaysia, Philippines, China, Hong Kong, Tropical Africa, Colombia, and Brazil. It was mostly cross-pollinated because of its monoecious nature; however, an andromonoecious sex form has been reported. The rate of cross pollination ranges from 60 to 80 per cent (Sivakami *et al*., 1987). It's an annual with enormous leaves and branching tendrils which can spread or climb up to 12 m. It is most commonly shape like a bottle, rectangular, oval, and

round. The skin of the immature fruit is light green to yellowish green or cream in color, soft with white pulp and large white seeds.

Mulching is important factor that impacts plant growth and yield (Barman *et al*., 2005). Mulching is the practices of covering the soil around a plant in order to improve growth, development, and crop production efficiency (Nagalakshmi *et al*., 2002). Also, it improves soil agrophysical properties through increasing microbial activity in the soil by raising soil temperature. Increased yields, earlier maturing crops, better quality product, insect management and weed control are benefits from using polyethylene (PE) films as mulch. Organic mulches will slowly decompose and release nutrients into soil while improving the soil structure. It has a high carbon to nitrogen ratio (such as saw dust) may cause temporary soil impoverishments in nitrogen due to activity of microorganisms. Leaf, straw, compost and saw dust, among some other organic materials have been used for organic mulch practices. Grass, rice straw and farm yard manure increases yields by 15 per cent, 26.5 per cent and 92.5 per cent (Khan *et al*., 2015).

Vermiwash is a mixture of excretory products and mucus secretion of earth warms water along with organic and inorganic material, symbiotic gut bacteria and fungi. It contains various enzymes mixture of protease, amylase, urease, and phosphatase. These are beneficial for plant growth and development and stimulate yield, and productivity of crops. It also contains growth hormones such as cytokinins, gibberellins and vitamins, along with micro and macro nutrients (Buckerfield *et al*., 1999). Panchagavya is a fermented liquid made by blending five ingredients obtained from cow, such as milk, urine, dung, curd and clarified butter. It contains several macronutrients *viz,* nitrogen, phosphorus, potassium and micronutrients Zn, Fe, Cu, Mn and also beneficial microorganisms like *Pseudomonas, Azotobacter, Agrobacterium*. Fish Amino Acid was made by fermenting fish by-products using sugar. It contains nitrogen (90 per cent) and phosphorus (2.5 per cent). It improves soil fertility and nutrients. It loosens the soil, maintains microbes in the soil active (Tarabily *et al*., 2003) and maintains a healthy soil environment. Present research work was planned to investigate the best effect of mulching and organic nutrients on certain growth and physiological characters of bottle gourd.

Materials and methods

The experiment was conducted in the farmer's field, Kothamangalam south, Alangudi Taluk which is located at 10°32' North latitude, 79°02' East longitude and at an altitude of ±90m above mean sea level in Pudukkottai district of Tamilnadu. The weather of Kothamangalam is moderately warm with hot summer months. The mean maximum temperature is 34.8 **°C** and minimum temperature is 22.7 **°C**, while the mean relative humidity is72 per cent and the mean annual rainfall is 286 mm After preparation of experimental plots, with mulching treatment [silver-black polythene mulch (25 µm) thickness, paddy straw mulch (8 cm) thickness and saw dust mulch (4 cm) thickness] were randomly distributed according to randomized block arrangement with three replications. Silver – black plastic mulches was laid by cutting into pieces of 5 m X 1m. After laying the mulch sheet, small circular holes of 10 cm diameter were made with scissors on the laid out sheets. Paddy straw mulch was applied at a thickness of 8cm (8 t ha^{-1}) and saw dust mulch was applied at a thickness of 4cm (8 t ha^{-1}) each on the bed. With spacing was given in experimental design for facilitating seed sowing. Mulch material was kept in the respective plots until the final harvest of bottle gourd. Seeds of bottle gourd cv. Punjab Komal were sown in lines @ two seeds per hill at a spacing of 2m between plants and 2.5m between rows. Sowing of the seeds was taken at a depth of less than 2 cm. Gap filling was done nine days after sowing. Thinning out was done after laying the mulch to maintain one plant per hill. A light surface irrigation was given

immediately after sowing. Observation was record at various stages of crop growth depending upon the type of observation. Observationwas done on five randomly selected plants from each treatment and replication. The data based on the mean of individual plants selected for observation were statistically analyzed described by (Panse and Sukhatme, 1967) to find out overall total variability present in the material under study for each character and for all the populations.

Result and discussion

The data on the influence of mulching and organic nutrients on the vine length of bottle gourd is presented in table 1. Among the various treatments maximum vine length was observed in (T_4) silver - black plastic mulch sheet (25 µm) thickness + vermiwash @ 5 % (50.72, 134.36, and 312.58 cm) at 25 DAS, 50 DAS and at final harvest respectively. It was followed by (T_2) silver - black plastic mulch sheet (25 µm) thickness + panchagavya @ 3 % (48.82, 129.55 and 297.44 cm). While, minimum vine length was observed in (T_{13}) control (31.25, 87.53 and 140.26 cm) at 25 DAS, 50 DAS and at final harvest respectively. Data presented in table 1 on number of leaves plant^{-1} reflected significant difference between the various treatments. Among the treatments the maximum number of leaves per plant was observed in (T_4) silver - black plastic mulch sheet (25 µm) thickness + vermiwash @ 5 % (45.59 and 112.33) at 35 DAS and at final harvest respectively followed by (T_2) silver - black plastic mulch sheet (25 µm) thickness + panchagavya @ 3 % (43.68 and 101.84) at 35 DAS and at final harvest respectively. The minimum number of leaves per plant was observed in (T_{13}) control (25.91 and 65.47) at 35 DAS and at final harvest respectively. The increase growth parameters were attributed to sufficient soil moisture near root zone resulted from minimization of evaporation loss as well as reduced weed growth due to mulching. Vermiwash contains biologically active substances such as plant growth regulator which enhance enough nutrient flow in the plant system, thereby, leading to increase in growth characters. The increase in plant growth parameters was also due to application of plastic mulch might be due to the favour soil moisture status and soil temperature which increases the turgidity of the cell with increase in available soil moisture leading to quicker cell division and enlargement. Plastic mulch reduced nutrient losses, weeds control and improved hydrothermal regimes of soil, which ultimately helps in increasing growth parameters of the plant. The result of the present study agrees with the findings of Singh *et al*. (2005) in bittergourd, Odedara (2011) in musk melon, Parmer *et al*. (2013) in water melon

There are significant influences with various treatments on total chlorophyll content. The maximum chlorophyll content was recorded in (T4) silver - black plastic mulch sheet (25 µm) thickness + vermiwash @ 5 % (16.63). It was followed by (T2) silver - black plastic mulch sheet (25 µm) thickness + panchagavya @ 3 % (16.09) which was on par with (T3) silver - black plastic mulch sheet (25 µm) thickness + fish amino acid @ 1 % (16.02). The minimum chlorophyll content was recorded in (T13) control 11.08 mg g-1.The combined application of (T4) silver - black plastic mulch sheet (25 µm) thickness + vermiwash @ 5 % was recorded maximum dry matter production per plant of 278.24 g. It was followed by (T2) silver - black plastic mulch sheet (25 µm) thickness + panchagavya @ 3 % (267.18 g) which was on par with (T3) silver - black plastic mulch sheet (25 µm) thickness + fish amino acid @ 1 % and the minimum dry matter production per plant was produced by T13 (148.31 g) control. The increase in chlorophyll content by the application of plastic mulch and vermiwash was due to the availability of micronutrient such as magnesium and zinc in traces in the organic manures and increases the uptake of nitrogen for protein synthesis, which would have indirectly influenced the photosynthetic activities resulting in better process of assimilation. Magnesium as nucleolus as nitrogen atoms as basic bricks of chlorophyll molecules, ultimately increase the photosynthetic activities which are associated with major photosynthetic process of plants (Gouda *et al*., 2001).

Similar results were observed by Anburani and gayathri, (2010) in onion, (Sangeeta *et al*., 2018) in bitter gourd.

Table:1

Effect of mulching and organic nutrients on certain growth and physiological characters of bottle gourd [*Lagenaria siceraria* (Molina) Standl.]" cv. Punjab Komal

Treatment	**Vine length (cm)**	**Number of leaves**	**Total chlorophyll content (mg g^{-1})**	**Dry matter production $plant^{-1}$ (g)**
T_1 - Silver - black plastic mulch sheet (25 µm) thickness	221.29	84.18	13.45	212.54
T_2 - Silver- black plastic mulch sheet (25 µm) thickness + panchagavya @ 3 %	297.44	101.84	16.09	267.18
T_3 - Silver- black plastic mulch sheet (25 µm) thickness +fish amino acid @ 1 %	297.23	101.78	16.02	267.11
T_4 - Silver- black plastic mulch sheet (25 µm) thickness + vermiwash @ 5 %	312.58	112.33	16.63	278.24
T_5 - Paddy straw mulch (8 cm) thickness	206.24	80.66	12.97	201.62
T_6 - Paddy straw mulch (8 cm) thickness + panchagavya @ 3 %	267.12	94.81	15.03	245.34
T_7- Paddy straw mulch (8 cm) thickness + fish amino acid @ 1 %	266.97	94.75	14.96	245.29
T_8 - Paddy straw mulch (8 cm) thickness + vermiwash @ 5 %	282.15	98.28	15.51	256.21
T_9 - Saw dust mulch (4 cm) thickness	191.16	77.21	12.46	190.71
T_{10} - Saw dust mulch (4 cm) thickness + panchagavya @ 3 %	236.87	87.74	13.99	223.49
T_{11}- Saw dust mulch (4 cm) thickness + fish amino acid @ 1 %	236.35	87.67	13.96	223.44
T_{12} - Saw dust mulch (4 cm) thickness + vermiwash @ 5 %	251.91	91.24	14.46	234.37
T_{13} – Control	140.26	65.47	11.08	148.31
SED	**7.51**	**1.71**	**0.22**	**5.29**
CD (p = 0.05)	**15.01**	**3.41**	**0.44**	**10.85**

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EFFECT OF INM ON NUTRIENT UPTAKE AND AVAILABLE SOIL NUTRIENT STATUS IN SNAKE GOURD (*Trichosanthes cucumerina* L.)

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Abstract

The experiment was conducted to assess the effect of INM on nutrient uptake and available soil nutrient status in snake gourd at Sithalavai village, Krishnarayapuram taluk, Karur district, Tamil Nadu, India during August to November 2021. The experiment was laid out in randomized block design with nine treatments replicated thrice. Organic manures used for the study were farm yard manure, vermicompost, phosphobacteria were applied as basal form and the biostimulants like seaweed extract and effective microorganism were foliar sprayed on three stages i.e. 20, 35 and 50 days after sowing. Results revealed that the application of vermicompost and seaweed extract along with recommended dosage of fertilizers increased total nitrogen uptake (135.78 kg ha^{-1}), total phosphorus uptake (34.93 kg ha^{-1}), total potassium uptake (157.69 kg ha^{-1}), available soil nitrogen content (165.47 kg ha^{-1}), soil phosphorus content (16.73 kg ha^{-1}) and soil potassium content (286.14 kg ha^{-1}). The experiment revealed that the plant nutrient uptake and post-harvest soil analysis were highly influenced by the application of vermicompost (5t ha^{-1}) and seaweed extract (3ml/litre) along with recommended dosage of fertilizers which is an environment friendly option for sustainable agriculture. The minimum values of all these characters were recorded under control.

Key words: *Organic manures, effective microorganisms, seaweed extract, nitrogen, phosphorus, potassium*

Introduction

Vegetables play a major role in Indian agriculture and responsible in solving problems of malnutrition among human population. Snake gourd (*Trichosanthes cucumerina* L.) is an important annual cucurbit, belongs to the family Cucurbitaceae. The immature fruits are used as vegetable and are a good source of minerals like Calcium, Magnesium, Phosphorus, fibres and other nutrients to make the food wholesome and healthy (Rahman *et al*., 2002). It has a prominent place in alternative systems of medicine like Ayurveda and Siddha due to its various pharmacological activities like antidiabetic, hepatoprotective, cytotoxic, anti inflammatory and larvicidal effects (Longman, 2002). The traditional method of farming and less use of organic manure reduces the quality of snake gourd. For increasing the productivity, economical fertilizer package needs to be formulated which can provide all the essential elements through both organic and inorganic sources to get good quality fruits, produce with higher production, keeping the production cost at sustainable level of an average farmer. Organic matter plays a key role to achieve sustainability on agricultural production because it possesses many desirable properties such as high-water holding capacity, cation exchange capacity and beneficial effect on the physical, chemical, and biological characteristics of soil. It also adds organic matter to the soil which may improve soil structure, aeration, soil moisture holding capacity and water infiltration (Sundararasu, 2017). Vermicompost is one of the most promising alternatives to costly chemical fertilizer and it has a higher level of available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous and soluble potassium, calcium, and magnesium derived from wastes (Meenakumari and Shekhar, 2012). Farm yard manure improves the soil structure, porosity, aeration, drainage, water retention capacity and

prevents the soil degradation (Singh *et al*., 2018). Being a biofertilizer, phosphobacteria enriches the diversity of soil microbes and maintains the soil fertility. Seaweed extracts (SWE) contain a wide variety of plant growth-promoting substances such as auxins, cytokinins, betaines, gibberellins, and organic substances, including amino acids, micronutrients and trace elements that improve crop yield and quality (Trejo *et al*., 2018). EM acts as a supreme in soil microbes which encourages other microbes to follow it and suppress the activity of smaller group of negative or opportunistic microbes (Joshi *et al*., 2019). Thus, the present study was conducted to find out the suitable combination of organic manures and biostimulants on nutrient uptake and soil available nutrient levels of Nitrogen, Phosphorus and Potassium by snake gourd.

Materials and Methods

The field experiment was conducted at Sithalavai village, Krishnarayapuram taluk, Karur district of Tamil Nadu during kharif season of 2021. The experimental area was a tropical region, located at 10.96˚North latitude and 78.28˚East longitude at an altitude of 98 m above mean sea level. The experiment was laid out in randomized block design (RBD) comprising of 9 treatments, replicated thrice. The treatments comprised of T_1 - RDF + FYM (12.5t ha^{-1}), T_2 - RDF + FYM (12.5t ha^{-1}) + Effective microorganisms (1:500), T_3 - RDF + FYM (12.5t ha^{-1}) + Seaweed extract (3ml/litre), T_4 - RDF + Vermicompost (5t ha^{-1}), T_5 - RDF + Vermicompost (5t ha^{-1}) + Effective microorganisms (1:500), T_6 - RDF + Vermicompost (5t ha^{-1}) + Seaweed extract (3ml/litre), T_7 - RDF + Phosphobacteria (2kg ha^{-1}), T_8 - RDF + Phosphobacteria (2kg ha^{-1}) + Effective microorganisms (1:500) and T_9 - RDF + Phosphobacteria (2kg ha^{-1}) + Seaweed extract (3ml/litre). The organic manures were incorporated into soil before sowing and the foliar application of biostimulants was applied at 20, 35 and 50 days after sowing. The recommended dose of fertilizers 60 kg N + 40 Kg P + 40 kg Kha^{-1} was applied as basal.

Snake gourd variety selected for study was Co-2. The seeds were sown at 2 x 1.5 m. The cultural operations *viz.,* field preparation, application of manures and fertilizers, staking and trellising, irrigation and plant protection were carried out as per the requirement of the crop. The plant nutrient analysis *viz.,* nitrogen uptake, phosphorous uptake and potassium uptake were taken from plant samples collected from the individual treatment at the time of harvest were dried in an oven at 60 ºC, powdered in a Willey mill and analysed for total nutrient content and the soil nutrient content were also observed. The data was recorded by taking five plants from each plot which was selected randomly. The statistical analysis of data was done by using DSAASTAT. For treatments showing significance, critical differences were worked out at five percent probability level. Net income was obtained by deducting all costs from gross income. B: C ratio was calculated by dividing the gross income with total cost of cultivation.

Results and Discussion

Nutrient uptake

The impact of organic manures and biostimulants on plant nutrient uptake of nitrogen, phosphorus and potassium content was found to be significant. Among the various treatments the highest nitrogen, phosphorus and potassium uptake was noted in T_6 (RDF + Vermicompost + Seaweed extract) with 135.78 kg ha^{-1}, 34.93 kg ha^{-1} and 157.69 kg ha^{-1} respectively. This was followed by T_8 (RDF + Phosphobacteria + Effective microorganisms (1:500)) with 131.26 kg ha^{-1}, 33.34 kg ha^{-1} and 151.37 kg ha^{-1} respectively. The least value was noted in T_1 (RDF + FYM - control) 107.28 kg ha^{-1}, 20.15 kg ha^{-1} and 114.55 kg ha^{-1} respectively.

Vermicompost enhanced N and P concentration and uptake in soil, increasing the solubilisation of P either by microorganisms' activation with excretion of organic acids likes citric,

glutamic, tartaric, succinic, lactic, oxalic, malic and fumaric or by higher phosphatise activity. The increase in K uptake by vermicompost application may be due to enhancement in K availability by shifting the equilibrium among the forms of K from relatively exchangeable K to soluble K forms in the soil. Prabha and Priya (2013) reported that vermicompost contains micro and macro plant nutrients in an easily available form that plants can easily assimilate for their growth and development. The highly stable macro and micronutrient content of the vermicompost has a unique time release quality. Due to this the nutrients in the vermicompost are released slowly and steadily as the plant needs them for growth. Further, several enzymes and hormones present in vermicompost in root zone would have resulted in increased availability and uptake of nutrients by the plants that are responsible for better yield attributes in vermicompost treated plots. Present finding is in agreement with the findings of Kashem *et al.* (2015) in tomato, Rai *et al.* (2016) in onion and Vigardt *et al.* (2020) in spinach. Seaweed extract is a new generation of natural organic fertilizers containing highly effective nutritious and promotes faster germination of seed and increase the yield and resistant ability of many crops (Dwivedi *et al*., 2014). The maximum yield of tomato (Zodape *et al*., 2011) and banana (Karthikeyan and Shanmugam, 2014) had been observed when using foliar application of *K. alvarezii* (Seaweed extract). Similar kind of result was observed by Pramanick *et al*. (2013) that the foliar application of seaweed extract improved the nutrient uptake capacity of crops. Similar results were reported by Halpern *et al*. (2015) where seaweed extract significantly increased the uptake of N, P and K. Also, seaweed extract containing oligosaccharides resulted in increased photosynthesis, basal metabolism, cell division and altered metabolic pathways for increased uptake and better assimilation of nitrogen.

Available soil nutrient status

The impact of organic manure and biostimulants on post-harvest soil nitrogen, phosphorus and potassium content was found to be significant. Among the various treatments the highest nitrogen, phosphorus and potassium availability was noted in T_6 (RDF + Vermicompost + Seaweed extract) with 165.47 kg ha^{-1}, 16.73 kg ha^{-1} and 286.14 kg ha^{-1} respectively. This was followed by T_8 (RDF + Phosphobacteria + Effective microorganisms (1:500)) with 163.16 kg ha^{-1}, 15.68 kg ha^{-1} and 279.80 kg ha^{-1} respectively. The least value was noted in T_1 (RDF + FYM - control) 141.43 kg ha^{-1}, 10.97 kg ha^{-1} and 246.44 kg ha^{-1} respectively.

Organic nitrogen, phosphorus and potassium availability in the soil increased with the application of vermicompost may be due to increase in the decomposition of products of organic matter (Ravanachandar and Lakshmanan, 2020). Moreover, vermicompost possesses high 'P' content. Application of vermicompost could be responsible for the high soil 'P' content. Increase in available N with organic sources might be attributed to the direct addition of nitrogen through organic sources to the available pool of the soil. Imthiyas and Seran (2015) reported that the build up of available NPK in the soil could be due to the organic acids which were released during the microbial decomposition of vermicompost and increased the available NPK in soil. These observations agree with the findings of Singh (2011) in rice-tomato-bottle gourd, Jadav *et al*. (2014) in radish. Application of sea weed extract helps the plants in different ways like plant health, increased rate of photosynthesis and crop yield. However, the post-harvest soil nutrient status indicated that organic manure and biostimulant application had great effect in soil nutrient status, it is necessary to study the effect on subsequent crop cycle since organic supplements has sustained release of nutrients. Similar findings were also expressed by Khan *et al*. (2009) and Bhuvaneshwari (2011) in radish.

Conclusion

The study strongly emphasis the role played by organic manures and seaweed extract in enhancing the nutrient uptake and available soil nutrients of snake gourd. If vermicompost and seaweed extract are used for organic farming, our dependence on chemical fertilizers can be reduced. It can be concluded that application of vermicompost and foliar spray of seaweed extract played a greater role in maintaining soil fertility, improve flowering and yield, enhance the quality and found to be profitable than farmer practices of organic snake gourd cultivation.

Table 1. Mean values on the effect of organic manures and biostimulants on plant nutrient analysis in snake gourd

Tr. No	Treatment details	Nutrient uptake (kg ha^{-1})		
		N	P	K
T_1	Control - RDF + FYM (12.5t ha^{-1})	107.28	20.15	114.55
T_2	RDF + FYM (12.5t ha^{-1}) + EM (1:500)	116.93	24.23	130.21
T_3	RDF + FYM (12.5t ha^{-1}) + SWE (3ml/litre)	123.76	27.76	137.62
T_4	RDF + VC (5t ha^{-1})	119.48	25.67	131.04
T_5	RDF + VC (5t ha^{-1}) + EM (1:500)	125.92	28.20	138.96
T_6	RDF + VC (5t ha^{-1}) + SWE (3ml/litre)	135.78	34.93	157.69
T_7	RDF + PSB (2kg ha^{-1})	112.31	21.54	122.53
T_8	RDF + PSB (2kg ha^{-1}) + EM (1:500)	131.26	33.34	151.37
T_9	RDF + PSB (2kg ha^{-1}) + SWE (3ml/litre)	129.46	30.74	143.85
S.ED		**2.32**	**0.53**	**2.58**
CD (p=0.05)		**4.92**	**1.12**	**5.48**

FYM - Farmyard Manure; EM - Effective Microorganism; SWE - Seaweed extract; VC - Vermicompost; PSB - Phosphobacteria

Table 2. Effect of organic manures and biostimulants on post-harvest soil nutrient status in snake gourd

Tr. No	Treatment details	Available soil nutrient (kg ha^{-1})		
		N	P	K
T_1	Control - RDF + FYM (12.5t ha^{-1})	141.43	10.97	246.44
T_2	RDF + FYM (12.5t ha^{-1}) + EM (1:500)	147.42	12.36	257.33
T_3	RDF + FYM (12.5t ha^{-1}) + SWE (3ml/litre)	153.25	13.41	264.59
T_4	RDF + VC (5t ha^{-1})	148.63	12.88	258.12
T_5	RDF + VC (5t ha^{-1}) + EM (1:500)	154.87	13.98	265.65
T_6	RDF + VC (5t ha^{-1}) + SWE (3ml/litre)	165.47	16.73	286.14
T_7	RDF + PSB (2kg ha^{-1})	143.74	11.74	251.46
T_8	RDF + PSB (2kg ha^{-1}) + EM (1:500)	163.16	15.68	279.80

T_9	RDF + PSB (2kg ha^{-1}) + SWE (3ml/litre)	158.51	14.81	272.52
S.ED		**2.88**	**0.26**	**4.99**
CD (p=0.05)		**6.11**	**0.54**	**10.58**

FYM - Farmyard Manure; EM - Effective Microorganism; SWE - Seaweed extract; VC - Vermicompost; PSB - Phosphobacteria

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EFFECT OF PHOSPORUS LEVELS AND BIOFERTILIZERS ON NUTRIENT UPTAKE AND ECONOMICS OF IRRIGATED BLACKGRAM

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Abstract

A field experiment was conducted at Kasthambadi Village, Polur Taluk, and Tiruvannamalai District during June - August, 2021 to study the effect of phosphorus levels and biofertilizers on yield components and yield of irrigated blackgram. The experiment consists of four main and six sub treatments was laid out in a split plot design with three replications. The main treatment consists of M1 - Control, M2 - 20 kg P2O5 ha-1, M3 - 40 kg P2O5 ha-1, M4- 60 kg P2O5 ha-1 through PROM and sub treatment consist of S1– Control, S2¬¬ - Seed treatment and soil application with Rhizobium, S3- Seed treatment and soil application with Phosphobacteria, S4- Seed treatment and soil application with Rhizophos, S5- Seed treatment and soil application with AM fungi and S6- Seed treatment and soil application with AM fungi + Rhizophos. The results of the field experiment on irrigated blackgram showed that thegrowth characters were significantly influenced by the application of different levels of phosphorus through PROM. Among the various levels of phosphorus (M3) applicationofP2O5@40 kg ha-1 through PROM had recorded the maximum values of seedyield(1,094kgha-1), haulm seed (1591 kg ha-1). And N- uptake of 89.18 kg ha-1, P- uptake of 13.88 kgha-1and K- uptake of 38.38 kg ha-1. The lower value of growth characters was recorded in control (M1). Among the sub treatments, seed treatment and soil application with AM fungi + Rhizophos (S6) has recorded a higher value of seed yield (1,050 kg ha-1), haulm seed (1550 kg ha-1) and recorded the highest N- uptake of 90.60 kg ha-1, P- uptake of 13.61 kg ha-1 and K- uptake of 38.35 kg ha-1, respectively. Lower value of growth characterwere recorded in control (S1). Among the different treatments, the interaction effect of phosphorous and biofertilizers M3S6 recordedsignificantly maximum seedyield (1198 kg ha-1), haulm seed (1685 kg ha-1) higher N, P and K uptake of 98.88, 15.20 and 41.62 kg ha-1, respectively with highest netreturnsRs. 48,010 ha-1with benefit cost ratio of 2.52 lower value was obtained in control (M1S1).

***Keywords**: Blackgram, PROM, Rhizophos and AM fungi*

Introduction

Blackgram is a major pulse crop cultivated in India that belongs to the "Leguminosae" family (*Vigna mungo* L.). Blackgram is a creation of the Indians. It isan ancient Indian crop that is more commercially useful than other pulses. A rich source of nutrients and energy is blackgram seeds. It is significantly richer than other grains in proteins (24%), carbohydrates (60%), lipids (1–5%), aminoacids, vitamins, and minerals. Blackgram isproduced on an area of 9.85 million hectares in India, with a productivity of 1,217 kg ha^{-1}. (Agricultural Stat, 2021) andTamil Nadu occupies an area of 3.70 lakh ha of 2.7 lakh tons production with 622 kg ha^{-1} productivity. Madhya Pradesh,

Maharashtra, Uttar Pradesh, Tamil Nadu, Orissa, and Gujarat are the chief blackgramgrowing states of India. Phosphorus (P) is one of the major essential macronutrients and it has beneficial effects on nodule stimulation, root development, growth and hastens maturity as well as improves quality of crop produces. Phosphorus is necessary for growth of Rhizobium bacteriaresponsible for N fixation for nodulation. Fixation of atmospheric N in leguminous crops is an energy- intensive process whichneeds phosphorus supply to meet its ATP requirement (Sanhthosh Kumar Raju and Sandeep Menon., 2020). Phosphate Rich Organic Manure (PROM) is a value-added product that is created by combining fine- grained, high-grade rock phosphate with organic matter gathered from a variety of sources, (Rajneesh Singh *et al*., 2021). Rhizobium is the bacteria that they convert dinitrogen into ammonia. Ammonia, being toxic in nature. is rapidly absorbed into organic compounds. When PSB is used with rock phosphate, it can save about 50%of the crop requirement of phosphatic fertilizer. The use of PSB as inoculantsincreases P uptake by plants (Porpavai and Nagarajan., 2020). By colonising the root cortex, AM fungus play a significant role inthe cycling and absorption of phosphorus (Khangarot *et al*., 2022).

Materials and methods

A field experiment was conducted at Kasthambadi Village, Polur Taluk, Tiruvannamalai District, Tamil Nadu during June – August, 2021. The experimental field was geographically situated at 12° 35´ North latitude and 79° 12´ East longitude at an altitude of 171meter (561 ft) above mean sea level. Thesoil of the experimental field was sandy clay loam, the soil was low in available nitrogen and phosphorus and medium in available potassium. The promising blackgram variety VBN 8 was chosen for the study. The experiment was laid out in split plot design with the three replications.The treatment comprised of the main treatment M1 - Control, M2 - 20 kg P2O5 ha^{-1}, M3 - 40 kg P2O5 ha^{-1}, M4- 60 kg P2O5 ha^{-1} through PROM and sub treatment consist of S1– Control, S2 - Seed treatment and soil application with Rhizobium, S3- Seed treatment and soil application with Phosphobacteria, S4- Seed treatment and soil application with Rhizophos, S5- Seed treatment and soil application with AM fungi and S6- Seed treatment and soil application with AM fungi + Rhizophos.

Results and Discussion

Effect on yield

Application of different treatments of PROM, PSB, Rhizobium, AM fungi andRhizophos in different combination significantly improved the various growth characters *viz.*, number of branches plant^{-1},seed yield, haulm seed and harvest index were significantly influenced on blackgram. Among the various levels of phosphorus (M3) application of P2O5 @ 40 kg ha^{-1} through PROM had recorded the maximum values of seed yield (1,094 kg ha^{-1}) and haulm yield (1591 kg ha^{-1}). The lower value of growth characters was recorded in control (M1).

Among the sub treatments, seed treatment and soil application with AM fungi + Rhizophos (S6) has recorded a higher value of seed yield (1,050 kg ha^{-1}) and haulm seed (1550 kg ha^{-1}) lower value were recorded incontrol (S1). Among the different treatments, the interaction effect of phosphorous and biofertilizers M3S6 recorded significantly higher seed yield (1198 kg ha^{-1}) and haulm seed (1685 kg ha^{-1}) least value was obtained in control M1S1. PROM is an organic source of nutrition and organic matter and supplies various essential nutrient with phosphorus which provided food for beneficial microorganism in field.

The PROM having other organic micro nutrients which might have resulted increased yield in blackgram. Similar inferences were also documented by Bhabai *et al*. (2019) and Yadav *et al*. (2017). When PROM applied in combination with biofertilizersencourages effective utilization of nutrientsand improved the availability of different nutrients and microbial inoculations in the soil. Application of AM fungi promoted theoverall development of plant in terms of root and shoot might have resulted in more absorption of nutrients and enhanced photosynthesis and production assimilates,which lead to increased plant height, number of nodules and dry matter accumulation. Similar result was reported by Patel *et al*. (2013), Singh *et al*. (2018), Bhabai *et al*. (2019) and Bhavna Singh Rathore *et al*. (2022). AM fungi and Rhizophos having phosphate solubilizing effect and survival of Rhizobium in the rhizosphere. PSB solubilize insoluble fixed P in soil by production of organic acids in solubilizing minerals and Rhizobium whichis present in the root nodules of the leguminous plants, add nitrogen to the soil which supplied to the plants to enhance their plant growth dissolution of insoluble phosphorus by Phosphobacteria in the soil,making it available to the crop plants for profuse root and vegetative growth and growth promoting substances produced by PSB. Similar result was also reported by Patel *et al*. (2013) Tabassum *et al.* (2016), Maya Yadav *et al.* (2017) and Ramalakshmi and Parimala Devi (2018).

Effect on Nutrient uptake

The data recorded on nutrient uptake of blackgram is significant. The main treatment, M3 (Application of P2O5 @40 kg ha^{-1}) recorded the highest N- uptake of 89.18 kg ha^{-1}, P- uptake of 13.88 kg ha^{-1} and K- uptake of 38.38 kg ha^{-1}, respectivelyand the main treatment M3 (Application of P2O5 @ 40 kg ha^{-1}). The least N, P and K uptake was recorded in the treatment M1 (Control) of 68.34, 9.98 and 31.84 kg ha^{-1}, respectively. Among the sub treatments,S6 (Seed treatment and soil application withAM fungi + Rhizophos) recorded the highest N- uptake of 90.60 kg ha^{-1}, P- uptake of 13.61 kg ha^{-1} and K- uptake of 38.35 kg ha^{-1}, respectively. The least N, P and K uptake was recorded in the treatmentS1 (Control). The interaction effect of phosphorus levels and biofertilizer were significantly influenced. Among the treatments M3S6 recorded the higher N, P and K uptake of 98.88, 15.20 and 41.62 kgha^{-1}, respectively. The control M1S1 registered lower N, P and K of 55.19, 9.25 and 26.81 kg ha^{-1}, respectively. Phosphorusapplication through PROM increased the photosynthetic activity of plants and helps to develop extensive root system which enable the plant to assimilate more photosynthates and increased the nutrient uptake. Similar results were reported by Islam *et al*. (2006) and Vennila, (2018). Application of AM fungi had shown to enhance and transfer soil nutrients to plant roots through their extrametrical hyphaethat extend beyond root depletion zone andincreased the root, shoot and nodule biomass and there by increased the NPK uptake. Similar result was reported by Harbans and Sudhir. (2021). Application ofPROM with recommend dose of N and K fertilizers increased the availability of nutrients to the all phenological stages of crop. PROM is a slow and steady release organic fertilizer, combined with biofertilizers increased the uptake of nutrient. Similar research findings were reported earlier by Dutta *et al.* (2021).

Effect on Economics

The treatment combination (M_3S_6) application of 40 kg P2O5 ha^{-1} through the PROM and seed inoculum and soil application of biofertilizer with Rhizophos and AM fungi recorded highest gross income of (Rs. 79,555 ha^{-1}) net returns of (Rs. 48,010 ha^{-1}) with B:C ratio of 2.52. Due to

higher seed yield in this treatment increased the gross and net return. Application of phosphorus through PROM and seed and soil inoculation of AM fungi and Rhizophos plays a beneficial role in sustainable agriculture as it is environmentally friendly, reliable, cost effective and easily available. This agrees with findings of Rajneesh *et al*. (2021) and Anju Kanwar *et al*. (2022). The least gross return, net returns, and B:C ratio recorded in (M1S1) control which receives no phosphorus and biofertilizers application. This is owing to low seed yield obtained in this treatment.

Table 1. Effect of phosphorus levels andbiofertilizers on seed yield (kg ha^{-1})

Sub plot treatment	Main plot treatment				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**
S_1	650	838	931	925	**836**
S_2	656	879	935	921	**848**
S_3	695	968	1158	1108	**982**
S_4	738	1045	1174	1121	**1020**
S_5	761	1003	1165	1115	**1011**
S_6	798	1078	1198	1125	**1050**
Mean	**716**	**969**	**1094**	**1053**	

	Main	**Sub**	**M at S**	**S at M**
S.Em±	11.20	1.54	13.36	10.26
CD (P=0.05)	54.81	7.56	65.36	50.22

Table 2. Effect of phosphorus levels and biofertilizers on haulm yield (kg ha^{-1})

Sub plot treatment	Main plot treatment				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**
S_1	1068	1328	1421	1411	**1307**
S_2	1085	1374	1424	1415	**1325**
S_3	1144	1468	1665	1621	**1475**
S_4	1245	1545	1681	1631	**1526**
S_5	1212	1502	1671	1627	**1503**
S_6	1291	1588	1685	1635	**1550**
Mean	**1174**	**1468**	**1591**	**1557**	

	Main	Sub	M at S	S at M
S.Em±	11.10	3.98	15.59	20.39
CD (P=0.05)	54.32	19.5	76.26	99.75

Table 3. Effect of phosphorus levels andbiofertilizers on nitrogen uptake (kg ha^{-1})

Sub plot treatment	Main plot treatment				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**
S_1	55.19	59.81	76.64	74.14	**66.45**
S_2	60.38	62.59	78.25	76.58	**69.45**
S_3	65.46	74.51	90.42	87.12	**79.38**
S_4	77.34	83.70	96.27	95.81	**88.28**
S_5	69.69	78.81	94.59	90.50	**83.40**
S_6	82.00	85.40	98.88	96.10	**90.60**
Mean	**68.34**	**74.14**	**89.18**	**86.71**	

	Main	Sub	M atS	S atM
S.Em±	1.33	0.19	1.57	1.42
CD (P=0.05)	6.55	0.95	7.69	6.95

Table 4. Effect of phosphorus levels and biofertilizers on phosphorus uptake (kg ha-1)

Sub plot treatment	Main plot treatment				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**
S_1	9.25	10.66	12.99	11.83	**11.18**
S_2	9.59	10.91	11.28	12.12	**10.98**
S_3	9.84	12.52	14.12	11.44	**11.98**
S_4	10.29	13.14	14.98	14.72	**13.28**
S_5	10.11	12.77	14.73	14.68	**13.07**
S_6	10.82	13.48	15.20	14.95	**13.61**
Mean	**9.98**	**12.25**	**13.88**	**13.29**	

	Main	**Sub**	**M atS**	**S atM**
S.Em±	0.16	0.04	0.24	0.21
CD (P=0.05)	0.79	0.21	1.19	1.04

Table 5. Effect of phosphorus levels and biofertilizers on potassium uptake (kg ha-1)

Sub plot treatment	**Main plot treatment**				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**
S_1	26.81	31.01	33.83	33.03	**32.62**
S_2	28.44	31.59	33.5	33.19	**31.68**
S_3	31.02	35.41	39.83	38.75	**36.25**
S_4	33.26	36.57	41.05	39.97	**37.71**
S_5	32.60	36.00	40.46	39.40	**37.12**
S_6	33.90	37.24	41.62	40.64	**38.35**
Mean	**31.84**	**34.64**	**38.38**	**37.50**	

	Main	**Sub**	**M atS**	**S atM**
S.Em±	0.15	0.10	0.30	0.25
CD (P=0.05)	0.77	0.53	1.48	1.25

Table 6. Effect of phosphorus levels andbiofertilizers on Economics

Treatments	Cost of cultivation(Rs ha^{-1})	Gross returns Rs ha^{-1}	Net returnsRs ha^{-1}	BCR
M_1S_1	28429	43318	14889	1.52
M_1S_2	28729	43725	14996	1.52
M_1S_3	28729	46319	17590	1.61
M_1S_4	28729	49215	20486	1.71
M_1S_5	29179	50677	21498	1.74
M_1S_6	29079	53161	24082	1.83
M_2S_1	28569	55798	27229	1.95
M_2S_2	28863	58509	29646	2.03
M_2S_3	28863	64388	35525	2.23
M_2S_4	28863	69470	40607	2.41
M_2S_5	29313	66697	37384	2.28
M_2S_6	29213	71658	42445	2.45
M_3S_1	30895	61936	31041	2.00
M_3S_2	31195	62199	31004	1.99
M_3S_3	31195	76935	45740	2.47
M_3S_4	31195	77991	46796	2.50
M_3S_5	31645	77396	45751	2.45
M_3S_6	31545	79555	48010	2.52
M_4S_1	33205	61536	28331	1.85
M_4S_2	33505	61280	27775	1.83
M_4S_3	33505	73641	40136	2.20
M_4S_4	33505	74496	40991	2.22
M_4S_5	33955	74102	40147	2.18
M_4S_6	33855	74760	40905	2.21

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EXPLORING HOST PLANT RESISTANCE AND DEVELOPING INTEGRATED NEMATODE MANAGEMENT STRATEGIES IN BRINJAL (*Solanum melongena* L.)

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Abstract

Root knot nematode, Meloidogyne incognita is the major nematode pest affecting successful brinjal production. As management by chemical means is relatively expensive and hazardous, there is always a need to develop integrated nematode management modules by judicial blend of several management options to reduce the use of chemicals. Experiments conducted at ICAR-Indian Institute of Horticultural Research, Bengaluru revealed that growing velvet bean (Mucuna pruriens var. utilis) as rotational crop and incorporation of its residues in soil significantly reduced the plant parasitic nematode population in soil. Field trials were conducted for two consecutive years (2020-2021 and 2021-2022) at ICAR –Indian Institute of Horticultural Research in brinjal cv. Arka Anand grown under field conditions to evaluate holistic modules by integrating cultural, biological, and chemical components for managing nematodes. Split plot design was adopted with velvet bean and marigold as rotational crops in main plots and testing of biological (Bacillus subtilis IIHR Bs-2) and chemical (Fluensulfone) components in sub plots, individually and in combination. Each treatment was replicated thrice. Results revealed pre-planting incorporation of velvet bean, application bioagent (Bacillus subtilis IIHR Bs-2) enriched FYM @ 5t/ha before planting, application of Fluensulfone @ 1g/plant at planting followed by soil drenching of bioagents at monthly intervals (5 ml/lit) recorded the lowest nematode population in soil (upto 89% decrease) and gall index (upto 91.12% decrease) and the highest yield (22.4 to 25.12% increase) compared to control. Hence this study proves that velvet bean and marigold serve as promising cultural components as rotational crops/cover crops for reducing plant parasitic nematodes and can be successfully integrated with biological and chemical control strategies for nematode management in brinjal.

Key words: *host plant resistance, crop rotation, brinjal, root knot nematode*

Introduction

Plant parasitic nematodes are one of the major biotic constraints limiting successful brinjal production throughout the world. Overall crop losses in brinjal due to plant-parasitic nematodes estimated through All India Coordinated Research Project on Nematodes stands at 21% amounting to Rs. 3499.12 million annually (Kumar *et al*., 2020). Regular outbreaks of root-knot disease caused by *Meloidogyne spp*. have occurred in recent years, impacting considerably on the yield of several horticultural crops. There is always a need to develop integrated nematode management modules by judicial blend of several management options to reduce the use of chemicals. Exploitation of host plant resistance is one of the safest and cheapest approaches to manage nematodes. Keeping these in view, field trials were conducted for two consecutive years (2020-2021 and 2021-2022) at ICAR –Indian Institute of Horticultural Research, Bengaluru in brinjal cv. Arka Anand grown under field conditions to evaluate holistic modules by integrating cultural, biological and chemical components for managing root knot nematodes, *M. incognita*.

Material and Methods

Nematicidal activity of velvet bean (*Mucuna pruriens* var. *utilis*) cv. Arka Ashwini was evaluated in polyhouse byincorporating its residues at 45 and 90 DAS. Initial and final plant parasitic nematode population was estimated before the start of experiment and after incorporation

of velvet bean residues in soil, respectively. The root exudates of velvet bean were analysed through GCMS and LCMS to identify the compounds possessing nematicidal activity.

Field trials were conducted in brinjal cv. Arka Anand grown under open field conditions for two successive years 2020-2021 and 2021-2022 in experimental fields at ICAR –Indian Institute of Horticultural Research, Bengaluruto evaluate holistic integrated modules for managing nematodes. Split plot design was adopted with velvet bean (cv. Arka Ashwini) and marigold (cv. Arka Madhu) as rotational crops in main plots (Fig. 1, 2 & 3) and testing of biological (*Bacillus subtilis* IIHR Bs-2) and chemical (Fluensulfone) components in sub plots, individually and in combination as follows. Each treatment was replicated thrice.

Main plot

M1: Incorporation of Mucuna

M2: Incorporation of Marigold

M3: Control

Sub plots

T_1 – Pre-planting application of nematicides (Fluensufone @ 1g/plant) and bioagent (*Bacillus subtilis* IIHR Bs-2) enriched FYM followed by soil drenching of bioagents at monthly intervals (5 ml/lit) recorded the lowest nematode population

T_2 – Pre planting application of Fluensulfone @ 1 g per plant

T_3 – Pre and post- planting application of bioagents (*Bacillus subtilis* IIHR Bs-2)

T_4 – untreated control

The data were statistically analysed and ANOVA was executed using SPSS ver.10.0.

Results and Discussion

Results revealed that growing velvet bean (*Mucuna pruriens* var. *utilis*) in polyhouse and incorporation of its residues significantly reduced the plant parasitic nematode population in soil to the extent of 49.1 to 61.9% (Fig. 4). GCMS analysis of the root exudates of velvet bean revealed several compounds of which di-butyl phthalate and hexadecanoic acid exhibited 70.51 and 64.53% nematicidal activity, respectively. LCMS profiling of root exudates of velvet bean revealed presence of compounds involved in salicylic acid pathway which are responsible for inducing host plant resistance. Similar results were observed by Yang *et al.* (2016) wherein di-butyl phthalate detected in root exudates nematode resistant tomato root stocks increased nematode (J2) mortality and prevented juvenile penetration into tomato roots.

The results of field trials conducted for two yearsin brinjal under open field conditions revealed that pre-planting incorporation of velvet bean, application bioagent (*Bacillus subtilis* IIHR Bs-2) enriched FYM @ 5t/ha before planting, application of Fluensulfone @ 1g/plant at planting followed by soil drenching of bioagents at monthly intervals (5 ml/lit) recorded the lowest nematode population in soil (upto 89% decrease) and gall index (upto 91.12% decrease) and the highest yield (22.4 to 25.12% increase) compared to control (Table 1 & 2). Osei et al. (2010) reported the potential of *Mucuna pruriens* as a cover crop in reducing mixed populations of root knot nematodes, *Meloidogyne* spp. Marigold is well known for its ability to produce nematicidal compound, alpha-terthienyl that is inimical to phytonematodes (Hooks *et al*., 2010). Also, Rao et al. (2017) demonstrated the efficacy of *Bacillus subtilis* IIHR Bs-2 enriched vermicompost in carrot which recorded 28.8% increase in carrot yield together with 69.3 % decrease in nematode population and 70.2% decrease in disease incidence. Hence this study proves that velvet bean and

marigold serve as promising cultural components as rotational crops/cover crops for reducing plant parasitic nematodes and can be successfully integrated with biological and chemical control strategies for nematode management in brinjal.

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Fig. 1: Velvet bean grown as rotational crop

Fig. 2: Marigold grown as rotational crop

Fig. 3: Evaluation of integrated nematode management strategies in brinjal

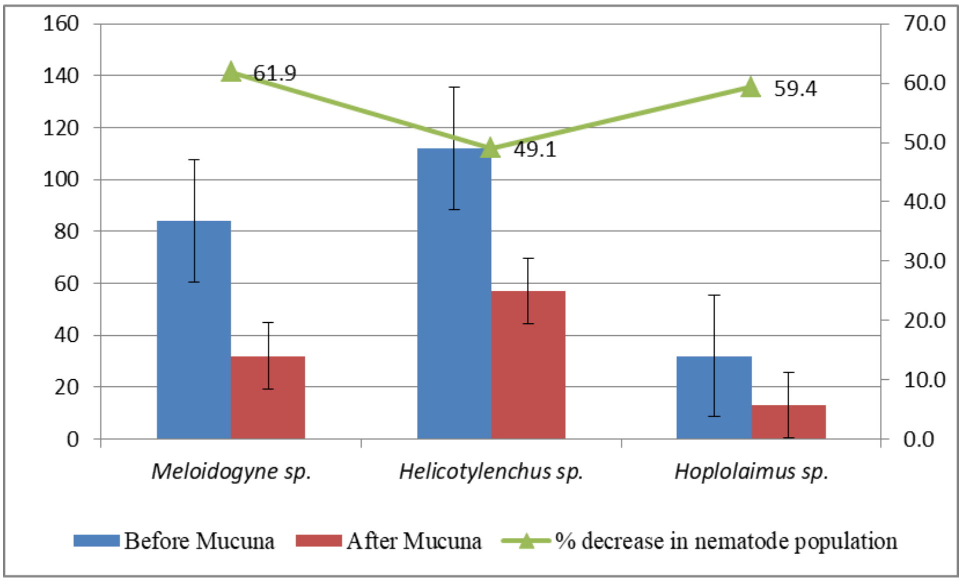

Fig. 4: Decline of nematode population after growing velvet bean (*Mucuna pruriens*)

Table 1: Evaluation of Management modules for nematodes in brinjal cv. Arka Anand under field conditions (Season – I : 2020-2021)

Treatments		**Nematode population in soil (per 250 cc)**	**% decrease in soil nematode population over control**	**Gall index**	**% decrease in gall index over control**	**Yield (t/ha)**	**% increase in yield over control**
M1 (Mucuna)	**T1**	**48.33^{a}**	**88.76**	**0.45^{a}**	**90.88**	**61.69^{a}**	**22.40**
	T2	81.67^{bc}	81.01	0.70^{b}	85.80	60.08^{bc}	19.20
	T3	97.00^{cd}	77.44	0.92^{c}	81.30	59.17^{d}	17.40
	T4	183.33^{g}	57.36	2.57^{i}	48.00	56.40^{f}	11.90
M2 (Marigold)	**T1**	**62.00^{ab}**	**85.58**	**0.74^{b}**	**84.91**	**60.58^{b}**	**20.20**
	T2	96.67^{cd}	77.52	1.03^{d}	79.10	59.42^{cd}	17.90
	T3	119.00^{de}	72.33	1.31^{f}	73.50	58.31^{e}	15.70
	T4	230.33^{h}	46.43	2.68^{j}	45.70	54.99^{g}	9.10
M3 (control without rotational crop)	T1	118.25^{de}	72.50	1.26^{e}	74.50	59.68^{cd}	18.41
	T2	133.30^{ef}	69.00	1.47^{g}	70.30	57.88^{e}	14.84
	T3	149.21^{f}	65.30	1.60^{h}	67.50	56.14^{f}	11.39
	T4	430.00^{i}		4.94^{k}		50.40^{h}	
	CD (0.05)	M – 43.92 T – 14.59 M at T – 48.71 T at M – 25.27		M – 0.04 T – 0.03 M at T – 0.06 T at M – 0.05		M – 1.46 T – 0.57 M at T – 1.65 T at M – 0.98	
	SE	M – 15.81 T – 6.94 M at T – 18.93 T at M – 12.03		M – 0.02 T – 0.01 M at T 0.03 T at M – 0.02		M – 0.32 T – 0.20 M at T – 0.43 T at M – 0.34	

[T1 – Pre-planting application of fluensulfone 1 g/plant and *B. subtilis* enriched FYM, followed by soil drenching of bioagents at monthly intervals; T2 – Pre planting application of chemical nematicides ; T3 – Pre and post planting application of bioagents ; T4 – untreated control]

Table 2: Evaluation of Management modules for nematodes in brinjal cv. Arka Anand (Season II 2021-2022)

Treatments		**Nematode population in soil (per 250 cc)**	**% decrease in soil nematode population over control**	**Gall index**	**% decrease in gall index over control**	**Yield (t/ha)**	**% increase in yield over control**
M1 (Mucuna)	**T1**	**49.00^{a}**	**89.00**	**0.44^{a}**	**91.12**	**61.93^{a}**	**25.12**
	T2	76.67^{bc}	82.78	0.68^{b}	86.27	60.23^{b}	21.68
	T3	100.67^{cd}	77.40	0.91^{c}	81.63	58.87^{c}	18.92
	T4	174.33^{g}	60.85	2.44^{h}	50.74	55.70^{ef}	12.53
M2 (Marigold)	**T1**	**63.00^{ab}**	**85.85**	**0.77^{b}**	**84.52**	**60.23^{b}**	**21.68**
	T2	97.67^{cd}	78.07	1.02^{d}	79.34	59.30^{bc}	19.80
	T3	116.67^{de}	73.80	1.28^{e}	74.16	57.53^{d}	16.23
	T4	206.33^{h}	53.67	2.65^{i}	46.43	53.13^{g}	7.34
M3 (control without rotational crop)	T1	111.00^{de}	75.07	1.20^{e}	75.71	58.84^{c}	18.86
	T2	131.33^{ef}	70.51	1.40^{f}	71.74	56.97^{de}	15.08
	T3	147.00^{f}	66.99	1.58^{g}	68.17	55.40^{f}	11.92
	T4	445.33^{i}		4.95^{j}		49.50^{h}	
	CD (0.05)	M – 13.66 T – 15.77 M T – 27.32		M – 0.05 T – 0.06 M T – 0.098		M – 0.64 T – 0.74 M T – 1.28	
	SE	M – 6.58 T – 7.60 M T – 13.18		M – 0.02 T – 0.03 M T 0.05		M – 0.31 T – 0.36 M T – 0.62	

[T1 – Pre-planting application of fluensulfone 1 g/plant and *B. subtilis* enriched FYM, followed by soil drenching of bioagents at monthly intervals; T2 – Pre planting application of chemical nematicides ; T3 – Pre and post planting application of bioagents ; T4 – untreated control]

A ROUND-UP OF CLIMATE CHANGE AND FARM ANIMAL WELFARE IN COASTAL REGION OF TAMIL NADU

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Abstract

This study perceives climate change impacts and adaptation strategies on farm animals to sustain livestock production in coastal region of Tamil Nadu.. Majority of the respondents perceived that climate change has negative impact on productive and reproductive performance of farm animals, increased incidence of diseases and parasitic infestation, decreasing trend of feed and fodder resources and water. Majority of the respondents perceived an increased environmental temperature, decreased precipitation, increased frequency of extreme weather conditions and summer season length. Most of the farmers preserved fodder crop in form of straw for adverse climatic condition, followed mixed livestock farming, diversifying farming practices, and changed planting date, provided bedding and warmth to their animals to protect them from extreme cold, similarly during hot days farmers provided cold water and shed to protect their animals as adaptation strategies for sustainable production.

Key Words: *Climate change impacts, Coastal region, Adaptation strategies, livestock production*

Introduction

The livestock production is an integral part of mixed farming systems practiced in the entire length and breadth of India (Varadharajan and Gnanasekar, 2018). Livestock sector contributes food to humans and is affected by climate change in our country. Climate change affects farm animals both directly and indirectly. Houghton et al. (2001) concluded that direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance: growth, milk production, wool production, and reproduction. The impact of climate change on animal production has been categorized by Rotter and Van de Geijn (1999) as: a) availability of feed grain, b) pasture and forage crop production and quality, c) health, growth, and reproduction and, d) disease and their spread. Animal health may be affected by climate change in four ways: heat-related diseases and stress, extreme weather events, adaptation of animal production systems to new environments, and emergence or re-emergence of infectious diseases, especially vector borne diseases which are critically dependent on environmental and climatic conditions.

Furthermore, while vulnerability to climate change has hardly been documented in the context of India; experimental studies have been conducted on effects of season and climate on production, performance, and other physiological parameters of farm animals. These studies have revealed that milk yield of crossbred cows in India (e.g., Karan Fries, Karan Swiss and other Holstein, and Jersey crosses) are negatively correlated with temperature-humidity index (Mandal et al. 2002a). The influence of climatic conditions on milk production has been also observed for local cows which are more adapted to the tropical climate of India. The estimated annual loss at present due to heat stress among cattle and buffaloes at the all-India level is 1.8 million tonnes, that is nearly two per cent of the total milk production in the country, amounting to a whopping over Rs 2,661 crore (Upadhaya, 2010). According to Tailor and Nagda (2005) heat stress has detrimental effects on the reproduction of buffaloes, although buffaloes are well adapted

morphologically and anatomically to hot and humid climate. Upadhya et.al, (2007) stated that thermal stress on Indian livestock particularly cattle and buffaloes has been reported to decrease oestrus expression and conception rate. Maurya (2010) concluded that the length of service period and dry period of all dairy animals was increased from normal during drought. The outbreak of the disease was observed to be correlated with the mass movement of animals which in turn is dependent on the climatic factors (Sharma et al. 1991). Singh et al., (1996) reported that higher incidence of clinical mastitis in dairy animals during hot and humid weather due to increased heat stress and greater fly population associated with hot–humid conditions. In addition, the hot–humid weather conditions were found to aggravate the infestation of cattle ticks like: *Boophilus microplus*, *Haemaphysalis bispinosa* and *Hyalomma anatolicum* (Basu and Bandhyopadhyay, 2004; Kumar et al., 2004). Keeping view in mid a study on climate change impacts on farm animals as perceived by farmers and adaptation strategies to sustainable production in coastal region of Tamil Nadu was conducted.

Material and Methods

The present study was conducted in coastal districts, Cuddalore and Nagapattinam of Tamil Nadu. Stratified randomly sampling technique was used for selection of blocks, villages, and respondents. From each district three blocks and six villages were selected. In this way 6 blocks and 12 villages from both the district were taken into consideration, from each selected village ten livestock owners having at least two large animals were selected randomly to make 120 total respondents for the investigation. Semi structured interview schedule was used for the purpose of data collection. Besides primary data, some necessary secondary data were also collected from department of Meteorology. Frequency distribution, percentage, mean score and Cattle equivalent score etc. were computed by using Statistical Package for Social sciences (SPSS) software and Microsoft excel.

Results and Discussion

Perceived impact of climate change on farm animals

Data presented in table 1 indicated that majority of respondents (80%) observed that climate change affects agriculture and animal husbandry, 59.2 percent perceived negative impact of climate change on productive performance of livestock, 57.6 percent told that climate change had negative impact on milk production and lactation length (60.1%). Around (52.5%) respondents said that climate change had positive impact on dry period. Majority of respondents (62.5%) perceived negative impacts of climate change on reproductive performance of livestock. Whereas (60.6%) respondents said that there were decreased length and intensity of oestrous period of their animals and (58.6%) respondents told that there were decreased conception rate of their animals. Many farmers told that there were increased cases of repeat breeding in their animals. Majority of respondents (62.4%) replied that climate change influences livestock disease incidences. Majority of respondents (84%) told that there were increased incidences of parasitic infestation in livestock. 80.6 percent respondents told that due to climate variability feed and fodder resources are decreasing and (96%) respondent's perceived shortage of dry fodder. Large number of respondents (96%) replied that there was decreased quantity of self grown fodder/grasses. In case of coastal regions of Tamil Nadu, respondents (80.6%) told that there was decreased availability and growth of fodder trees whereas 19.4 percent observed it stayed constant and (86%) respondents replied that there were decreased water resources. Majority of respondents (86%) replied that there was depletion of ground water level. About 70 percent respondents told that there was decreased

availability of water for irrigation. Majority of respondents (79.2 %) replied that there was decreased number of natural water resources.

Table1: Perceived impact of climate change on farm animals

Sl.No.	Perceived impact	Percentage
1	Climate change affects agriculture and animal husbandry	80
2	Negative impact of climate change on productive performance	59.2
3	Negative impact on milk production	57.6
4	Negative impacts on lactation length	60.1
5	Positive impact on dry period	52.5
6	Negative impacts on reproductive performance	62.5
7	Decreased length and intensity of oestrous period	60.6
8	Decreased conception rate	58.6
9	Effect on livestock disease incidences.	62.4
10	Increased incidences of parasitic infestation in livestock	84
11	Feed and fodder resources are decreasing	80.6
12	Shortage of dry fodder	96
13	Decreased water resources	96
14	Depletion of ground water level	86
15	Decreased availability of water for irrigation	70
16	Decreased number of natural water resources	79.2

Livestock management strategy adopted by farmers under climatic change scenario

Over centuries, livestock producers have traditionally adapted to climatic changes by building on their in-depth knowledge of the environment in which they live. Farmers own perception and local traditional knowledge help them in evolving measures and technique to deal with situations arising due to climatic variations. These measures and techniques are locale specific, require no external help and are inherently scientific. Documentation of such practices and techniques, farmer to farmer dissemination and sharing such innovative approaches at large platforms have helped in influencing research agenda of academic institutions and setting the priorities.

- Change in livestock/herd composition (large animal vs. small animal during adverse climatic conditions
- Reduction in livestock number
- Replacement of exotic breeds to local breeds
- Keeping more livestock and reducing reliance on crops
- Preservation of fodder
- Crop diversification
- New fodder crop variety/type
- Change planting dates

- Provide bedding for livestock during extreme winter/cold
- Plantation fodder tree lines around animal shed/ house to reduce effects of cold/ heat waves
- Selling of livestock in order to buy food
- Migration along with livestock during adverse climatic conditions
- Livestock insurance
- Farming to non- farming (Business)
- Rain water harvesting

Other coping strategy adopted by farmers of Coastal Tamil Nadu

- Provide cold water during hot and humid climate.
- Provision of shade to reduce heat stress.
- Provide fresh air/ fan/cooler during extreme hot condition.
- Kept their animal outside during night during summer.
- Loose housing system.
- Freed their animal during adverse climatic condition in search of feed and safe place.
- Elevated animal house/shed/shelter.
- Constructing "Manchans"(hanging bamboo platforms inside houses)
- Rotational lopping of vegetative biomass of fodder trees, shrubs, herbs and grasses.
- To minimize landslide, they were started to conserve forest, promote plantation and safe landing of running water during the rainy period

Coping strategies of farmers to various climate vagaries vary from household to households and region based existing support system and their indigenous knowledge.

Conclusion

There is a serious threat of climatic changes (in the form of severe droughts, floods, intense rainfall, and landslides) undermining development programmes and millennium development goals aimed at reducing poverty. Climate induced disasters directly affect the livelihood of the farmers. Since livelihood of the farmers is based on agriculture and animal husbandry, all the respondents reported that decrease in the animal- agricultural production weakened the economic condition. Currently India is spending 2.5% of its total GDP on measures to control the adverse impact of climatic change, which is a big amount for any developing nation. As livestock is and will play very important role in rural economy, it is necessary to find suitable solution to reduce the ill effect of climate change on livestock production.

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EFFECT OF COMPOSTS AND INDUSTRIAL BY-PRODUCTS ON SESAME YIELD AND POST HARVEST NUTRIENT STATUS

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Abstract

Sesame is the oldest Indigenous oil seed crop with longest history of cultivation in India. The Indian Agricultural Scenario become grimmer due to unabated depletion of nutrients. Soil fertility is the most limiting factor for crop production in sandy clay loam soil. The problems severely affect the productivity of sesame in this region. The present investigation was carried out to study the effect of conventional and non-conventional organic sources and industrial by-products in yield and post harvest nutrient status. The treatments include 100% RDF as control (25:50:75 N:P_2O_5:K_2O kg ha^{-1}) 100% and 75% RDF with municipal solid waste compost, poultry manure compost, bagasse ash and wood ash @ 5 t ha^{-1} and 10 t ha^{-1}. There were 9 treatments combination and design followed was RBD and replicated 3 times. Among various treatments combined applications of 75% RDF + Poultry manure @ 10 t ha^{-1} through soil application (T_5) recorded the highest seed yield (1157.84 kg ha^{-1}) and stalk yield (2262.5 kg ha^{-1}). The same treatment recorded highest post harvest soil organic carbon (3.11 kg ha^{-1}), available N (186.41 kg ha^{-1}), available P (19.45 kg ha^{-1}), available K (438.72 kg ha^{-1}), exchangeable Ca (5.35 mg kg^{-1}), Mg (2.08 mg kg^{-1}) and available S (9.46 mg kg^{-1}).

Keywords: *Sesamum, Poultry manure, Seed yield, Stalk yield, Post harvest nutrient status*

Introduction

Sesame (*Sesamum indicum)* or gingelly is commonly known as ellu (Tamil) – Sesame seed (Contain 50% oil, 25% protein and 15% carbohydrate) is used in baking, candy making and other food industries. It is an integral part of rituals, religion and culture sesame meal is an excellent high-quality protein (40%) feed for poultry and livelihood India ranks first in world with 27.04 million hectares area and 33.42 million tones production (Agricultural Statistics at a Glance, 2020). A well managed crop of sesame can yield 1200-1500 kg ha^{-1} under irrigated and 800-100 kg ha^{-1} under rainfed conditions (Ranganatha, A.R.G. Improved Technology for Maximizing Production of Sesame, 2013).

Municipal solid waste compost used as treatment for non-conventional organic source to be included as one of the components in trial waste generation rates will be more than double over the next 20 years in lower income waste management costs have been increased about 5 times in low-income countries and form times in lower-middle income countries (Hownweg and Bhade-Tata, 2012). These ever-growing large amount of wastes are associated with environmental and public health problems, and odor from the land fills. The reuse of wastes for agricultural purpose to improve soil properties and increase crop yield in a good solution for minimizing these problems poultry manure.

Poultry population is raising every year leaving large amount of poultry ripens. Poultry manure contains nutrient elements that can support crop production and enhance the physical and chemical properties of soil. Poultry manure application improves soil retention and uptake of plant nutrients (Mohammed Amanullah *et al.,* 2010).

Bagasse is an important agro-industrial waste by-products that in generally used as a food in sugar milling industry. The ash is an alkaline material, certain K, Ca, Mg and P. The main goal of this study was to assess the potential use of ash from combination of sugarcane bagasse as a fertilizer (Schimenz and Eichlezobermenn, 2010).

Wood ash is the inorganic and organic residue remaining after combination of wood or unbleached wood fibre. Ash is composed of many major minor elements which trees need for growth. Field research confirms the safety and practically of recycling wood ash on agricultural levels. The objective of field experiment was to study the direct effect of organic manures like municipal solid waste compost, poultry manure, industrial by-products like bagase ash and wood ash on yield and post harvest nutrient status of N, P, K, Ca, Mg and S (UGA Co-operative Extension Bulletin, 1142, 2013).

Materials and Methods

Field experiment

A field experiment at Annamalai Kottai village, Kodumudi taluk, erode district to be carried out to study the effect of soil application of RDF as control, RDF with Municipal Solid Waste Compost @ t ha^{-1} and 10 t ha^{-1} RDF with poultry manure compost @ 5 t ha^{-1} and 10 t ha^{-1}, RDF with Bagasse ash @ 5 t ha^{-1} and 10 t ha^{-1} RDF with wood ash @ 5 t ha^{-1} and 100 t ha^{-1}. The experiment was conducted in a Randomized Block Design (RBD) with the following nine treatments and each treatment was replicated 3 times.

The objectives of this experiment to evaluate seed yield and stalk yield and post harvest nutrient status of NPK and secondary nutrients.

Treatment details of the field experiment

T_1 – Control – 100% RDF (25:50:75 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2 – 100% RDF + Municipal solid waste compost @ 5 t ha^{-1}

T_3 – 100% RDF + Municipal solid waste compost @ 10 t ha^{-1}

T_4 – 100% RDF + Poultry manure @ 5 t ha^{-1}

T_5 – 100% RDF + Poultry manure @ 10 t ha^{-1}

T_6 – 100% RDF + Bagasse ash @ 5 t ha^{-1}

T_7 – 100% RDF + Bagasse ash @ 10 t ha^{-1}

T_8 – 100% RDF + Wood ash @ 5 t ha^{-1}

T_7 – 100% RDF + Wood ash @ 10 t ha^{-1}

The chemical composition of municipal solid waste compost, poultry manure, bagasse ash and wood ash are furnished in Table 1.

Seed yield (kg ha^{-1})

Seed yield of the net plot was recorded after hand threshing and air drying. After recording the seed yield of net plot area, seed yield ha^{-1} was worked out and expressed in kg ha^{-1}.

Stalk yield (kg ha^{-1})

The plants from the net plot area after threshing were dried and weight was recorded. Stalk yield per ha was worked out and expressed as kg ha^{-1}.

Soil samples were collected just before the commencement of field experiment and at harvest to determine the various physico-chemical characteristics and nutrient status of soil. The collected soil sample were air dried in shade ground in wooden mallet passed through 2 mm sieve and stored in polythene bags. These samples were analyzed for pH, EC, organic carbon, available NPK, exchangeable Ca and Mg and extractable sulphur. The details of procedure followed for the analysis for the analysis of soil samples are listed in Table 2.

Results and Discussion

Seed yield

The first and foremost aim of the present investigation is to increase the sesame productivity through suitable INM practices. Associated with improved growth and yield character the sesame yields also increased with the application of 75% RDF + Poultry manure @ 10 t ha^{-1} (T_5). The increase in yield with application of poultry manure and chemical fertilizers could be attributed to better uptake of essential nutrients and the transformation of economic parts as well as improving in yield attributing characters like number of capsules $plant^{-1}$, number of seeds $plant^{-1}$, seed weight $plant^{-1}$ and 1000 seed weight. The pronounced effect of poultry manure might have helped in enhancing the enzyme and photosynthetic activities, accumulation of photosynthates there by higher seed yield. Further increased in photosynthesis during growth stages might the contributed for greater assimilates supply to the capsules which resulting in better seed setting and also betterment of higher seed yield of sesame. The results in conformity with Haruna (2011).

Among the industrial by-products the application of 100% RDF + Bagasse ash @ 5 t ha^{-1} (T_6) registered highest seed yield. This is due to the supply of nutrients, conductive physical environment leading to better aeration, increase in soil moisture holding capacity, root activity and nutrient absorption and the consequent complementary effect due to bagasse ash have resulted in higher seed yield of 1044.31 kg ha^{-1}. This was line with the findings of Thind *et al.* (2012).

Stalk yield

The highest stalk yield of 2262.5 kg ha^{-1} was recorded in application of 75% RDF + Poultry manure @ 10 t ha^{-1} (T_5). The significant increase in stalk yield is due to the addition of poultry manure to an agricultural soil increased the contents of nutrients available with biochemical and microbiological transformation in soil. The beneficial changes in soil properties with compost amended treatments positively affect the stalk yield (Eifediyi *et al.,* 2018).

Among the industrial by-products the highest stalk yield was recorded in the treatment T_6 (2092.19 kg ha^{-1}). This may be due to bagasse ash resulted in higher concentration in sesame stalk and in turn better growth of crop (Fundora onliga *et al.,* 2010).

Post harvest soil nutrient status

Post harvest organic carbon

The highest post-harvest soil organic carbon (3.81 g kg^{-1}) was recorded in the treatment receiving 75% RDF + Municipal solid waste compost @ 10 t ha^{-1} (T_3). The highest organic carbon content in soil applied with municipal solid waste compost might have stimulated the microbes by serving as source of carbon, energy and other nutrients essential for their growth and multiplication and thus increased the soil activities. Residual organic carbon content was higher in organic manure treated soils that in control slow mineralization of organic matter might lead to the buildup of organic carbon (Insam *et al.,* 2009).

Post harvest soil nitrogen

The maximization post-harvest soil N recoded 186.41 kg ha^{-1} in the treatment T_5 receiving 75% RDF + Poultry manure @ 10 t ha^{-1}. The mixing of RDF and poultry manure reduced N loss and increased post harvest N content (Zhao and Fuzhen, 1992). The soil physical and chemical properties improved by the addition of poultry manure increasing total nitrogen (Trupiano *et al.,* 2017).

Post harvest soil phosphorus

The highest post-harvest soil P recorded 19.45 kg ha^{-1} in the treatment receiving 75% RDF + Poultry manure @ 10 t ha^{-1} (T_5). The increased P availability to plants to the solubilization of P by organic acids present in the poultry manure (Singh and Amberga, 1991). An increase in the inorganic P concentration in the soil is due to the application of poultry manure. The higher soil liable P was increased with the addition of composted poultry litter (Gagnon and Simond, 2003).

Post harvest soil potassium

The highest post-harvest soil potassium (438.72 kg ha^{-1}) was recorded in the treatment 75% RDF + Poultry manure @ 10 t ha^{-1} (T_5). The higher available K content under combined poultry manure and fertilizer treatment in the current study may be ascribed to the release of organic acids during decomposition, which generates negative electron charges in the soil with a preference for di or trivalent cations such as Al^{3+}, Ca^{2+} and Mg^{2+} leaving K+ to be absorbed by negatively charged soil colloids. This phenomenon might help to reduce K fixation and enhance its availability in soil (Anas Iqbal, 2019).

Post harvest Ca, Mg and S

The maximum post harvest soil Ca (5.35 Cmol (P^+) kg^{-1}), Mg (2.08 Cmol (P^+) kg^{-1}), in the treatment receiving 75% RDF + Poultry manure @ 10 t ha^{-1} (T_5). Ca and Mg levels increased with the rate of poultry manure application (Pool *et al.,* 2000). The higher exchangeable Mg observed in poultry manure treated tools implies higher rate of mineralization of Mg. The higher organic content of the poultry manure could have probably accounted for the residual exchangeable Mg content of soil. This agreed with Dinesh *et al.* (2012). The highest post harvest soil of the sulphur (9.46 mg kg^{-1}) was recorded in the treatment receiving 75% RDF + Poultry manure @ 10 t ha^{-1} (T_5). The integrated role of applied organic manure is more pronounced for availability of sulphur in the soil, may be released active organic acids during microbial activity that enhanced the oxidation of sulphur (S^0) from the native and added sources to sulphate form (SO_2^{4-}). The combined application of fertilizer with poultry manure, the available content of sulphur in soil significantly increased (Venugopal *et al.,* 2017).

Conclusion

Considering the salient findings in perspective, study revealed that application of 75% RDF + Poultry manure @ 10 t ha^{-1} (T_5) was found to be the best combination for maximizing yield and post harvest and nutrient status of NPK, Ca, Mg and S.

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Table 1. Chemical composition of municipal solid waste compost poultry manure, bagasse ash and wood ash

Manures and industrial by-products	OC (g kg^{-1})	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
Municipal solid waste compost	27.0	1.13	2.92	0.53	7.88	0.50	0.25
Poultry manure	14.9	2.23	0.83	2.35	1.42	0.58	0.50
Bagasse ash	71.5	0.014	0.0052	0.024	1.38	0.75	0.13
Wood ash	18.5	0.000006	0.09	5.91	1.93	0.68	0.01

Table 2. Methods of analysis of soil

S. No.	Parameters	Methodology	References
A	**Mechanical fraction**		
1	Textural fractions	International pipette method	Piper (1966)
2	Bulk density, Practice density and pore space	Measuring cylinder method	Sree Ramlu (2003)
3	Soil colour	Munsell soil colour chart	U.S. Dept. of Agriculture Hand Book (2000)
B	Physico-chemical properties		
4	Soil reaction, pH	Potentiometry (1:2:5 soil:suspension)	Jackson (1973)

5	Electrical Conductivity	Conductometry (1:2.5 soil: suspension)	Jackson (1973)
6	Cation exchange, CEC	Neutral normal ammoniumacetate method	Jackson (1973)
C	Chemical properties		
7	Organic carbon	Chromic acid wet digestion method	Walkley and Black (1934)
8	Available nitrogen ($KMNO_4$-N)	Alkaline permanganate method	Subbiah and Asija (1956)
9	Available phosphorus (Olsen-P)	Ascorbic acid blue method (spectrophotometry)	Watanabe and Olsen (1965)
10	Available potassium (NH_4 OAcK)	(Neutral 1N NH_4OAc extract) flame photometry	Standford and English (1949)
11	Ca,Mg	Versenate method	Jackson (1973)
12	S	Turbidometric method using spectrophotometric at 420 nm	Chesnin and Yein (1956)

Table 3. Effect of conventional, non-conventional organic source and industrial by-products on seed yield and stalk yield

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
T_1 – Control 100% RDF	922.9	1974.56
T_2 – 100% RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	1045.43	2117.8
T_3 – 100% RDF + Municipal Solid Waste Compost @ 10 t ha^{-1}	1100.51	2185.81
T_4 – 100% RDF + Poultry manure @ 5 t ha^{-1}	1124.12	2219.64
T_5 – 100% RDF + Poultry manure @ 10 t ha^{-1}	1157.84	2262.5
T_6 – 100% RDF + Bagasse Ash @ 5 t ha^{-1}	1044.31	2092.19
T_7 – 100% RDF + Bagasse Ash @ 10 t ha^{-1}	1007.21	2025.64
T_9 – 100% RDF + Wood Ash @ 5 t ha^{-1}	1006.09	2023.39
T_7 – 100% RDF + Wood Ash @ 10 t ha^{-1}	938.64	1976.02
Mean	1038.56	2097.54
S.Ed.	3.32	4.37
CD (p=0.05)	6.90	9.26

Table 4. Effect of conventional, non-conventional organic source and industrial by-products on post-harvest organic carbon, NPK status of soil

Treatments	OC (kg ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 – Control 100% RDF	2.36	173.96	18.8	420.1
T_2 – 100% RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	3.67	178.91	19.58	433.5
T_3 – 100% RDF + Municipal Solid Waste Compost @ 10 t ha^{-1}	3.81	179.1	19.6	434.28
T_4 – 100% RDF + Poultry manure @ 5 t ha^{-1}	3.08	184.83	19.37	436.9
T_5 – 100% RDF + Poultry manure @ 10 t ha^{-1}	3.10	186.41	19.45	438.72
T_6 – 100% RDF + Bagasse Ash @ 5 t ha^{-1}	2.39	177.2	19.0	421.91
T_7 – 100% RDF + Bagasse Ash @ 10 t ha^{-1}	2.41	176.72	18.9	422.62
T_9 – 100% RDF + Wood Ash @ 5 t ha^{-1}	3.43	175.8	19.19	446.35
T_7 – 100% RDF + Wood Ash @ 10 t ha^{-1}	3.29	175.69	19.21	448.46
Mean	3.06	178.73	19.23	433.65
S.Ed.	0.0243	0.174	0.0117	0.423
CD (p=0.05)	0.0515	0.37	0.0249	0.897

Table 5. Effect of conventional, non-conventional organic source and industrial by-products on post-harvest Ca, Mg and S status of soil

Treatments	Ca (c mol (P^+) kg^{-1})	Mg (c mol (P^+) kg^{-1})	S (mg kg^{-1})
T_1 – Control 100% RDF	5.30	2.01	8.83
T_2 – 100% RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	5.42	2.03	9.10
T_3 – 100% RDF + Municipal Solid Waste Compost @ 10 t ha^{-1}	5.48	2.05	9.25
T_4 – 100% RDF + Poultry manure @ 5 t ha^{-1}	5.33	2.06	9.44
T_5 – 100% RDF + Poultry manure @ 10 t ha^{-1}	5.35	2.08	9.46
T_6 – 100% RDF + Bagasse Ash @ 5 t ha^{-1}	5.32	2.13	9.08
T_7 – 100% RDF + Bagasse Ash @ 10 t ha^{-1}	5.31	2.14	9.0
T_9 – 100% RDF + Wood Ash @ 5 t ha^{-1}	5.38	2.09	8.9
T_7 – 100% RDF + Wood Ash @ 10 t ha^{-1}	5.36	2.11	8.85
Mean	5.36	2.08	9.10
S.Ed.	0.0025	0.0027	0.0094
CD (p=0.05)	0.0053	0.0058	0.02

STUDIES ON *PER SE* PERFORMANCE AND VARIABILITY FOR GRAIN NUTRITIONAL QUALITY IN POPULAR AND INDIGENOUS RICE (*Oryza sativa L.*) GENOTYPES OF TAMILNADU, INDIA.

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Abstract

*The goal of the current study was to aspect the per se and variation in grain nutritional qualities across 33 rice germplasm lines. All five variables had highly significant differences, as verified by ANOVA, representing the existence of genetic variation among the genotypes examined. G24 had high protein content whereas G10 had high zinc content. Among the genotypes, G22 recorded high manganese content and G25 exhibited high Iron content. Maximum copper content is recorded by G8. Micronutrient content is usually low in cereal crop especially iron and zinc, genotypes G10 and G25 had high zinc and iron content amid the genotypes.*Copper, zinc, manganese, and iron were *revealed to had high PCV and GCV values with high heritability and high genetic advance as % of mean was recorded for the characters viz., zinc, manganese, iron, copper and protein.Genotypes viz., Aathurkichili samba, TRY 1, Sivappu kavuni and Kanthasala were identified as superior for grain nutritional qualities wouldbenominatedtoincreaseparticularmicronutrientaimed atcropenrichment or may be exploitedas donor parent in hybridization programme.*

***Keywords**: Micronutrients, traditional varieties, variability, protein*

Introduction

Rice (*Oryza sativa* L.) is the world's most significant cereal crop and it aids as the chief source of energy for two-thirds of the world's population. Rice represents a significant status in many countries due to its role in traditional diets and as the primary source of income for many people across the world (Madhubabu *et al*., 2017). With a productivity of 2717 kg ha-1, India ranks first in area (45769 million hectares) and second in rice production (124368 million tonnes) (www.indiaagristat.com, 2021-22). Because of its superior nutritional value and improved digestion, rice has garnered its status as the queen of grains. Iron deficiency can cause anaemia, and poor maternal iron consumption has been associated to autistic spectrum condition in children (Black *et al.,* 2013). According to Cichy *et al*. (2005), 49 percent of the world's population is at threat of insufficient zinc consumption. Zinc is a fundamental micronutrient for tissue growth, wound healing, connective tissue growth and maintenance, immune system function, prostaglandin generation, bone mineralization, correct thyroid function, blood coagulation, cognitive processes and prenatal growth (Nachimuthu *et al.,* 2014). Micronutrient insufficiency is seen as a significant menace to food and nutrition security, particularly in developing countries, and there is growing recognition of a food-based approach to addressing it (Maganti *et al*., 2020). Since rice is mostly ingested as a whole grain, grain quality attributes are critical in rice breeding. Quality attributes include milling %, grain appearance, cooking quality, and nutritional components. Proteins and micronutrients such as iron and zinc are nutritional components. Rice grains have an average protein content of 8%. The amino acid profile reveals that it is high in Glutamic acid and Aspartic acid, with the highest quality cereal protein being high in Lysine (3.8 percent), the first limiting

amino acid; Fe is 1.2 mg/100 g, and Zn is 0.5 mg/100 g (Babu*et al.*,2012). Appropriate breeding programmes should be utilized to increase the content of micronutrients in the grain. The current study's objective is to assess the per se performance and genetic variability among the genotypes for nutritional quality attributes while taking the views into consideration.

Materials and Methods

The experiment was conducted between the growing seasons of 2021 and 2022 at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar (Chidambaram), Tamil Nadu, India. The genotypes adopted in this research were from TRRI and the Nel Jayaram Institute- Kudavasal which included 14 popular and 19indigenous Tamil Nadu cultivars. The experimental material was planted in a Randomized Complete Block Design with three replications of 10 rows each, with 15 plants per row, were used to plant the genotypes. A single seedling is kept on each hill. The proper mandatory recommendations were followed. Grain samples were gathered from each genotype and replication to analysed nutritional quality features such as protein, zinc, manganese, iron and copper using Atomic Absorption Spectrometer. Per se performance and genetic variability studies were analysed by TNAUSTAT software.

Results and Discussion

The first step in starting a breeding programme to develop micronutrient-rich genotypes is screening of available germplasmand identifying the source of genetic variation for the target trait, which can be used in crosses, genetic studies, molecular marker development, and understanding the basis of micronutrient uptake process.

Table 1 displays the analysis of variance for all nutritional attributes that were analysed. The analysis of variance for different characteristics was statistically examined, and it was discovered to be significant for all of the features studied. The genotypes that were analysed were all genetically varied. Per se performance for the trait Protein (%), the rangeo fprote in ranged from5.83%to7.87%with grandmean value of 7.13 %. G24 hadhigh protein content, whereas G1had **l**ow protein. For Zinc (ppm), therangebetween19.37ppmand 85.50 ppm with grand mean value 36.53 ppm.

Zinc is a vital element that boosts immunity, resistance to illness, and optimal nervous system growth and development. Zinc insufficiency affects 17.3 percent of the worldwide population due to dietary inadequacies, while in some parts of the world, up to 30 percent of the population is at danger. G10 and G22 had high and low zinc content respectively (Table3). With the grandmean value48.99ppm, them anganese content ranged from 35.29 ppm to 88.56 ppm. Among all 33 genotypes G22 has recorded high manganese content and G8 observed forlow manganese content (Table 2).

Iron (ppm) ranged from 1.01 ppm to 3.76 ppm. G25 exhibited high Ironcontent, whereasG21h adminimumiron content value. Mean value of copper ranges from 0.58 ppm to 7.48 ppm. Maximum coppercontentisrecordedinG8andminimumcopper contentisobservedinG24. One of the frameworks facilitates in the production of nutritious food suited for all ages is the process of developing varieties with high protein and nutrients using traditional or contemporary breeding methods (Watanabe *et al.*, 2006; Graham *et al.,* 2001; Gregorio *et al.*, 2000). The genetic variability of nutritional content in rice grain was studied and depicted in Fig 1. Copper, zinc, manganese, and iron were shown to have high GCV and PCV values. For high iron concentration (Ravindrababu *et al*., 2012), Patil (2014), and Chakraborty *et al*., (2009), comparable findings were found; for high

zinc content Madhubabu *et al*., (2017), and Ravindrababu *et al*., (2012). Because of their high genetic variability, these qualities have a higher magnitude of phenotypic and genotypic coefficients of variation, implying that they have the potential for selection throughout crop growth. High heritability and genetic advance as a percentage of mean were observed for the characteristics zinc, manganese, iron, copper, and protein (Table 3). These findings were consistent with those of the following authors: Yasmin *et al*., (2019), Madhubabu *et al*., (2017) and Chakraborty *et al*., (2017) got comparable protein content values.

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EEFECT OF PLANT GROWTH PROMOTING RHIZOBACTERIA ON GROWTH AND YIELD OF TUBEROSE (*Polianthes tuberosa* L.)

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Abstract

Rhizospheric bacteria can fix atmospheric nitrogen, Solubilizing phosphorus, iron and producing hormones viz., auxins, gibberellins and cytokinins and promote plant growth by directly affecting the metabolism of the plants by providing substances that are usually in short supply. Plant growth promoting rhizobacteria prevents the deleterious effects of phytopathogenic microorganisms. In the present study ten different locations from Thiruvannamalai andDharmapuri district were selected and the rhizosphere soil of tuberose were collected and analysed. From these locations ten isolates of each Azospirillumand Pseudomonas were screened for their PGPR traits such as nitrogenase activity, IAA, Siderophore production. The isolates namely AzospirillumlipoferumCAZS-7 and Pseudomonas fluorescens CPS-10 were showed maximum in all the above character were selected for the development of bioinoculant. The selected bioinoculant with 50%, 75% and 100% NPK as single and dual inoculant were studied for their efficacy of growth and yield of Tuberose (Polianthes tuberosa L.) were investigated under pot culture. The results obtained revealed that application of PGPR to Tuberose plant was significant influence the vegetative growth, flowering production, the application of 75% NPK with Azospirillumand Pseudomonas to tuberose plants was most effective in influencing most of the parameters rather than recommended dose of fertilizer.

Keywords: Tuberose, Rhizosphere and PGPR.

Introduction

Tuberose (*Polianthes tuberosa* L.) is one of the most important ornamental bulbous flowering plants cultivated to produce long-lasting flower spikes. It is popularly known as Rajanigandha orNishigandha. It belongs to the family Amaryllidaceae and is native to Mexico.In India tuberose is produced in both tropical and subtropical regions. Tuberose is popularly used as loose, cut flower as well as in perfumery industry. Its cut flower used in bouquets, vase decoration and various floral arrangement whereas loose flower used for making garland, flower ornaments for bridal makeover and in various industry for essential oil, concrete, absolute. The flowers remain fresh for long time and withstand long distance transportation and find the useful place in the flower market. It is a prominent plant in Indian culture and mythology Sangavai and Chellapandi, (2008). As per the area and production statistics of the National Horticulture Board (2013) in India, the total area under tuberose cultivation in the country is about 7.95 lakh hectares. The indiscriminate use of chemical fertilizers has led to substantial pollution of soil, air and water Gupta *et al*., (2015).High cost of nitrogenous and Phosphatic fertilizers is also another factor to be considered for a developing country like ours. PGPR are important soil bacteria living in the plant rhizosphere and bulk soil. These rhizosphere bacteria are known to be able to enhance plant growth through directly or indirectly (Kumar*et al*.,2014). The use of PGPR has shown potential is a promising technique in the practice of sustainable agriculture (Goswami *et al*., 2016). Keeping this in view,

the present investigation was undertaken with the objective to evaluate the effect of co-inoculation of effective rhizospheric bacteria on growth and yield in tuberose. The current work targets isolation and identification of plant growth promoting rhizobacteria from various plant rhizosphere.

Materials and Methods

The well grown tuberose plant with intact roots was uprooted from the field and excess soil was removed. The soil adhered to root surface and in between the roots were collected and used as rhizosphere soil and stored in refrigerator at 4ºC and used for the microbiological study. The rhizosphere soil was collected in ten different places around theThiruvannamalai and Dharmapuri district and is used to isolate the PGPR bacteria such as *Azospirillum*and *Pseudomonas*. Based on the sample collection, the isolates *Azospirillum*and *Pseudomonas* were designated as CAZS-1 to CAZS-10, CPS-1 to CPS-10 respectively. Efficient PGPR isolates were selected and used in field experiment. The efficient strains were selected on the basis of their Nitrogenase activity and cell Nitrogen content ,IAA production, Gibberellic acid (GA_3) production, siderophore production potential for our study.

Preparation of pots and bulbs inoculation

The cement pots of size 1’x 2’x 2’ filled with garden land soil and sand in the ratio of 1:1. The bulbs of tuberose was surface sterilized with 80 per cent ethanol and 0.1 per cent mercuric chloride and washed the bulbs with sterile distilled water for 3 to 4 times.

The bulbs were mixed with carrier based PGPR bioinoculants as single and dual of microorganisms separately having a cell load of $1x10^9$ cfu ml^{-1} and shade dried for 30 min. After shade drying, the bulbs were sown at 3 bulbs per pot. The fertilizer schedule of 200: 200: 200kg of NPK ha^{-1} was followed based on the treatments. A control pot without inoculation was also maintained. The experiment was conducted in Completely Randomized Block Design (CRBD) design with three replications. The treatments are as follows.

Treatment details of the pot culture experiment

T_1 - Control, T_2 -100% RDF, T_3 - *P. fluorescens* CPS-10, T_4 - *A. lipoferum*CAZS-7, T_5 - Co-inoculation *(P. fluorescens* CPS-10 + *A. lipoferum*CAZS-7), T_6 - *(P. fluorescens*CPS-10 + *A. lipoferum*CAZS-7) +50% NPK, T_7 - *(P. fluorescens*CPS-10 + *A. lipoferum*CAZS-7) +75% NPK, T_8 - *(P. fluorescens*CPS-10 + *A. lipoferum*CAZS-7) +100% NPK.

Biometric observation:

Plant height (cm)

The height was recorded at 90^{th}, 120^{th}, and 150^{th} days after planting. The height was measured from ground surfaces to the tip of the plant and expressed in cm.

Chlorophyll content (mg g^{-1})

The chlorophyll content was estimated at 90 days after planting by the method of Yoshida *et al*., 1971 from the fully expanded third leaf from the tip and was expressed in mg g^{-1}.

Dry matter production (g $plant^{-1}$)

The plants were uprooted, cleaned and dried in hot air oven at 60ºC to het a constant weight of the plant and expressed in kilogram $ha^{-1.}$

Flower yield $plant^{-1}$ (g)

The fresh weight of the flower produced per plant was weighted and was expressed in grams.

Statistical analysis

The statistical analysis of data was carried out for the experiments as suggested by Panse and Sukhatme (1978).

RESULTS

Table -1 Effect of PGPR and chemical fertilizer Inoculation on the height (cm) of Tuberose (*Polianthes tuberosa L.*) under pot culture condition.

Treatments	**Plant height (cm)**		
	90 DAP	**120 DAP**	**150 DAP**
T_1	25.62	33.07	41.50
T_2	31.33	39.01	45.64
T_3	35.29	41.63	49.35
T_4	38.12	47.59	57.45
T_5	42.74	51.71	62.93
T_6	46.51	57.87	67.81
T_7	53.06	61.91	69.38
T_8	54.85	62.88	71.26
SED	0.903	1.05	1.189
CD=(P=0.05)	1.807	2.100	2.379

Fig.1 Plant height of tuberose

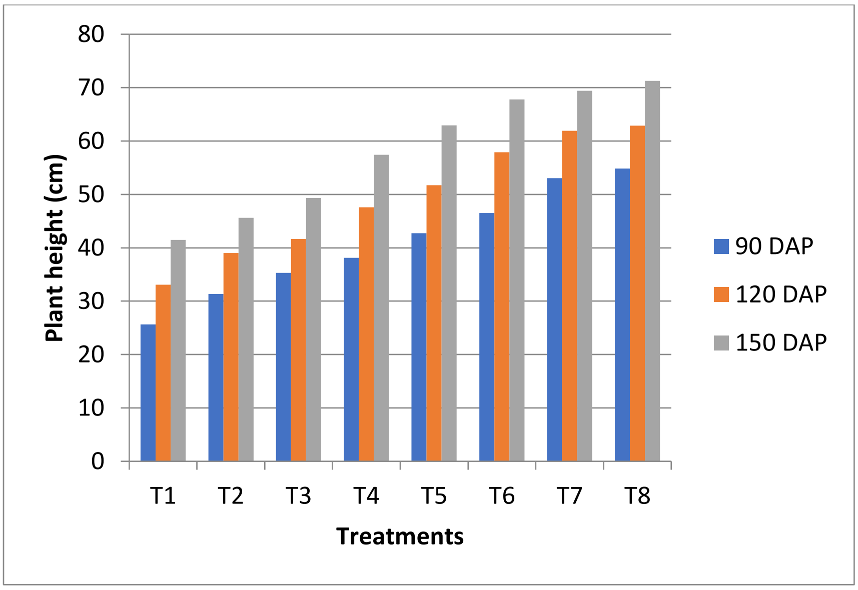


Table -2 Effect of PGPR and chemical fertilizer Inoculation on Chlorophyll content (mgg^{-1}) of Tuberose (*Polianthes tuberosa L.*) under pot culture condition

Treatments	Chlorophyll content (mg g^{-1})
T_1	0.602
T_2	0.648
T_3	0.721
T_4	0.762
T_5	0.824
T_6	0.861
T_7	0.897
T_8	0.931
SED	0.017
CD=(P=0.05)	0.034

Table -3 Effect of PGPR and chemical fertilizer Inoculation on Dry matter production (g plant^{-1}) of Tuberose (*Polianthes tuberosa L.*) under pot culture condition

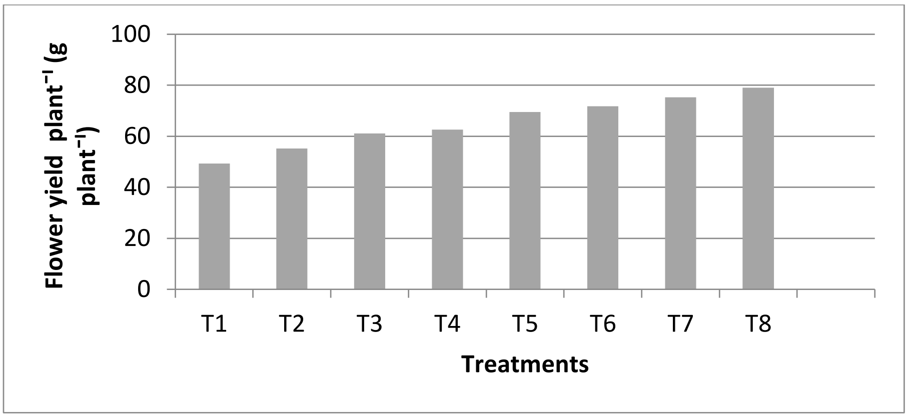
Treatments	Dry matter production (g plant^{-1})
T_1	18.44
T_2	20.35
T_3	22.91
T_4	23.51
T_5	25.26
T_6	26.86
T_7	27.12
T_8	29.81
SED	0.49
CD=(P=0.05)	0.985

Table -4 Effect of PGPR and chemical fertilizer Inoculation on Flower yield plant^{-1} (gplant^{-1}) of Tuberose (*Polianthes tuberosa L.*) under pot culture condition

Treatments	Flower yield plant^{-1} (g plant^{-1})
T_1	49.33
T_2	55.26
T_3	61.16
T_4	62.56
T_5	69.57
T_6	71.81

T_7	75.29
T_8	79.10
SED	1.336
CD=(P=0.05)	2.672

Fig.2 Flower yield of tuberose



The Plant height of Tuberose

The effect of PGPR and Chemical fertilizer inoculation on the Plant height of Tuberose was measured and the results are furnished in Table-1. Among the eight treatments tested, the maximum Plant height was recorded in the treatment T_8 (*Azospirillumlipoferum*CAZS-7 + *Pseudomonas fluorescens*CPS-10 + 100% NPK) (71.26 cm) and the treatment T_7 (*Azospirillum lipoferum* CAZS-7 + *Pseudomonas fluorescens* CPS-10 +75% NPK) (69.38 cm) was on par with T_8. Minimum Plant height was recorded in the treatment T_1 (Control) (41.50 cm) respectively (Fig.1). Ahmad *et al*., (2014) stated that the treatment containing *Azospirillum* had recorded maximum values in terms of plant height, florets spike^{-1}, Spike length, Florets fresh weight and earlier sprouting in gladiolus plant. Yadav (2022) also obtained similar result in tuberose plant concluded that the application of PGPR with different growth media increase the plant height.

The chlorophyll content (mg g^{-1}) of Tuberose

The data pertaining to Chlorophyll content of the plant have been shown in table -2 indicates that plant Chlorophyll content significantly influenced by inoculation of*Azospirillum* and *Pseudomonas*strains and their interactions. The maximum Chlorophyll content (mg g^{-1}) was recorded in the treatment T_8 (*Azospirillum lipoferum*CAZS-7 + *Pseudomonas fluorescens* CPS-10 + 100% NPK) (0.931 mg g^{-1}) followed by the treatment T_7*Azospirillum lipoferum*CAZS-7 + *Pseudomonas fluorescens* CPS-10 + 75% NPK) (0.897 mg g^{-1}). The treatment T_7 was at par with T_8. The Minimum chlorophyll content (mg g^{-1}) was recorded in the treatment T_1(Control) (0.602 mg g^{-1}). Domenico (2020) conducted an experiment in *Ranunculus asiaticus* shows that the microorganisms are able to improve the performance of zeolitite, use of zeolites enriched with PGPR can significantly increase the physiological parameters like the photosynthesis rate and chlorophyll content.

The Dry matter production (g plant^{-1}) of Tuberose

It is inferred from the data presented in table 3 that dry matter production was observed maximumin the treatment T_8 (29.81g plant^{-1}) and the treatment T_7 (27.12 g plant^{-1})was on par with T_8. Minimum

Dry matter production (g plant^{-1}) was recorded in the treatment T_1 (Control) (18.44 g plant^{-1}) respectively. Kumari*et al*., (2015) reported that the increase in dry weight of chrysanthemum due to the activity of rhizobacteria found in the roots.

The Flower yield plant^{-1} (g plant^{-1}) of Tuberose

The results shows that the microorganismare able to improve the Flower yield plant^{-1} (g plant^{-1}) of Tuberose was evaluated and are presented in Table-4. Among the interactions between *Azospirillum* and *Pseudomonas*strains, the maximum Flower yield plant^{-1} (g plant^{-1}) was recorded in the treatment T_8 (79.10g plant^{-1}) and the treatment T_7(75.29g plant^{-1})was on par with T_8. Minimum Flower yield plant^{-1} (g plant^{-1}) was recorded in the treatment T_1(Control) (49.33gplant^{-1}) respectively (Fig.2).Kuldeep Yadav *et al*., (2015) In Gerbera plants inoculated with mix culture of *G. Mosseae* +*A. laevis* + *P.fluorescens* shows maximum number of flower yield.Godse *et al*.,(2006) who observedthatplantsreceiving vermicompost 8 t ha^{-1}+ Azotobacter and PSB @ 25 kg ha^{-1}each + 80% RDF significantly increased yield and quality attributes of gladiolus viz., number of spikes ha^{-1}., length of spike and number of florets spike^{-1}when compared with RDF and other treatments.

Conclusion

The results obtained revealed that application of PGPR to Tuberose plant was significant influence the Plant height, Dry matter production, Chlorophyll content and flower yield.The application of 75% NPK with *Azospirillum*and *Pseudomonas* to tuberose plants was most effective in influencing most of the parameters rather than recommended dose of fertilizer.

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INVASIVE WEEDS MANAGEMENT BY SUBMERGENCE TOLERANT RICE VARIETY AND HERBICIDES IN CAUVERY DELTA ZONE

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Abstract

The present investigation was conducted to evolve a suitable weed management practice for invasive alien weeds in transplanted rice under submerged condition at Annamalai University Experimental Farm. The experiments were laid out in a split plot design with the conventional rice and submergence tolerant rice varieties compared in main plot. Weed management practices, viz. unweeded control, twice hand weeding (at 30 and 45 DAT), butachlor 1.5 kg/ha, bensulfuron-methyl 0.06 + pretilachlor 0.6 kg/ha and oxadiargyl 0.07 kg/ha were compared in sub treatments. The results indicated that submergence tolerance as a biological or genetic trait in crops helped suppressing invasive alien weeds like Leptochloa chinensis and Marsilea quadrifolia, offering biotic resistance to invasion by alien weeds and when integrated with weed control measures. Hence, weed control in submergence tolerant rice with the application of bensulfuron-methyl 0.06 + pretilachlor 0.6 kg/ha could be suggested as an efficient weed control programme for monsoon transplanted rice crop.

Keywords: Invasive, Submergence tolerant, CDZ, Herbicides, Climate change

Introduction

Rice cultivation in wetlands are characterized by transplanted mode of cultivation with standing water and crop growing seasons coinciding with monsoon rains. Frequently, excess rainfall during monsoon results in flash floods that lead to complete submergence of the crop. Alteration in the precipitation and evaporation pattern, more number of wet years annual rainfall excess by ten per cent or more resulting in frequent inundation or flooding resulted in invasion of rice fields of Cauvery river delta in India (Kathiresan 2009).

Traditional and popular rice varieties are prone for their susceptibility to complete submergence. Accordingly, submergence tolerant rice varieties are introduced and are being increasingly cultivated as they withstand complete submergence up to ten days. They do not suffer any yield loss compared to conventional varieties (Manzoor *et al.* 2018). Phytosociological survey of floristic composition of weeds in Cauvery delta zone revealed the recent invasion of the wetland rice fields by alien invasive weeds *Leptochloa chinensis* and *Marsilea quadrifolia*. These two weed species dominated over the native weed such as *Echinochloa colona*. And others by virtue of their amphibious adaptation to alternating flooded and residual soil moisture conditions prevalent during recent years in this region (Kathiresan and Gulbert 2016). Herbicides have become the major weed management tool in rice crop. Hence the present investigation conducted to trace the infestation by invasive alien weeds and yield losses in rice cultivar compared.

Materials and Methods

Field experiments were conducted during *samba (Kharif)* seasons of consecutive years at Annamalai university experimental farm, Department of Agronomy, Annamalainager, Tamil Nadu. The soil was clayey loam with a pH of 7.09. The available nitrogen, phosphorus and potassium content in the soil were 227.4, 19.7 and 342.5 kg/ha respectively. The experiment was laid out in split plot design with three replications. The main plot treatments comprised conventional and

submergence tolerant rice varieties namely *BPT* (5204) and *Siggapi* (*CR1009 sub1*). The weed management practices were compared as sub-plots. They included two hand weedings, butachlor 1.5 kg/ha, bensufuronmethyl 0.6 + pretilachlor 6% GR 10 kg/ha and oxadiargyl 0.07 kg/ha. The weed flora was allowed to grow without any disturbance throughout the crop duration in the unweeded control. Hand pulling of weeds was done once at 30 DAT and again at 45 DAT in twice hand weeded plots. In herbicide treatments, the herbicides were sprayed by using knapsack sprayer fitted with flood jet deflector nozzle using 600 L/ha water. Butachlor formulation used was 50% EC 1.25 kg/ha, granular bensulfuron methyl 0.06 + pretilachlor 0.6 kg/ha was mixed with 50 kg sand/ha and they were applied on 4th day after transplanting, oxadiargyl 80% WP was sprayed 0.07kg/ha on 3rd day after transplanting. A thin film of water was maintained at the time of herbicide application. The crop was manured with 150 kg N, 50 kg P and 50 kg K2/ha, with half dose of N (75 kg/ha) and full dose of phosphorus (60 kg/ha) and potassium (50 kg/ha) as basal before transplanting. The remaining half nitrogen (75 kg/ha) was top dressed in two equal splits at tillering and panicle initiation stages. Thirty days old seedlings were transplanted in the main field with a spacing of 20x15 cm. The plants were exposed to submergence with water depth of 50 cm after 10 days of transplanting during the field experimentations for seven days and there after normal water depth of 10 cm was maintained.

All other agronomic and plant protection measures were adopted as per the recommended packages. The data on weed density (60 DAT) was recorded with the help of a quadrate of 0.25 m^2. Weed control index of each treatment plot was calculated by using the following formula suggested by Misra and Tosh (1979) and recorded in percentage.

$$WCI = a/a-b*100$$

Where,

a= weed biomass in unweeded control plot

b= weed biomass in treatment plot

Production for the cropping Systems interm of yield were also computed and recorded. The experimental data were statistically analyzed following analysis of variance and least significant difference was worked out at 5% probability level.

Results and Discussion

Effect on weeds and crop

The weed flora was dominated by *Leptochloa chinensis* and *Marsilea quadrifolia*. Other weeds like *Cyprus rotundus*, *Bergia capensis, Eclipta alba*, *Acalypha indica*, and *Echinocloa colona*, were also present but were sporadic in frequency and negligible in occurrence. Among the conventional and submergence tolerant rice varieties tried submergence tolerant rice variety was found to be superior by recording the least population of weeds.

This was because of better vegetative growth and canopy coverage during the vegetative phases of the crop growth that suppressed the establishment of *Leptochloa chinensis* and *Marsilea quadrifolia.* The competitive edge is attributable to the physiology of submergence tolerance in the variety *Sigappi* that surpassed the hydrophytic adaptation of the both the invasive alien species. This finding is supported by the earlier reports of Reddy *et al*. (2012). Weed management practices influenced the weed population greatly. All the weed management treatments resulted in control of weed population. Among the weed control measures compared, the application of bensulfuron-methyl 0.06 + pretilachlor 0.6 kg/ha were significantly superior to the other treatments.

Bensulfuron-methyl 0.06 + pretilachlor 0.6 Kg/ha offered effective control of annual grasses and broad leaf weeds (*Leptochloa chinensis* and *Marsilea quadrifolia)* (**Table 1**). This finding is supported by the earlier reports of Anbhazhagan and Kathiresan (2008).

Among the conventional and submergence tolerant rice varieties tried '*Sigappi*' excelled with the highest weed control index of 67.51 and 66.67% during both the seasons. Conventional variety recorded the lowest weed control index of 63.84 and 62.65% during both the seasons. Among the weed control treatments, application of bensulfuron-methyl 0.06 + pretilachlor 0.6 kg/ha recorded the highest weed control index of 94.9 and 91.03% during both the seasons. The interaction effects between rice varieties and weed management were also significant (Gnanavel and Kathiresan 2002) (**Figure 1**).

Submergence tolerant rice variety exhibited higher yields of 4.09 and 4.54 t /ha during both seasons, respectively. (**Table 3**) This finding is supported by Yamano *et al.* (2013).

Conclusion

The results indicated that submergence tolerance as a biological or genetic trait in crops helped suppressing invasive alien weeds like *Leptochloa chinensis* and *Marsileaquadrifolia*, offering biotic resistance to invasion by alien weeds and when integrated with weed control measures were efficient in suppressing these alien weeds. Hence, weed control using submergence tolerant rice along with the application of bensulfuron-methyl 0.06 + pretilachlor 0.6 kg/ha could be suggested as an efficient weed control programme, for monsoon transplanted rice crop in Cauvery delta zones of tamilnadu.

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Table 1. Individual weed species count on 60 DAT (m^{-2})

Treatments	*Cyprus rotundus*		*Bergia capensis*		*Eclipta alba*		*Acalypa indica*		*Echinocloa colonum*		*Leptochloa chinensis*		*Marsilea quadrifolia*	
	1st Year	**2nd Year**	**1st Year**	**2nd Year**	**1st Year**	**2nd Year**	**1st Year**	**2nd Year**	**1st Year**	**2nd Year**	**1st Year**	**2nd Year**	**1st Year**	**2nd Year**
Conventional variety	2.05 (3.73)	1.95 (3.34)	1.90 (3.13)	1.76 (3.1)	1.70 (2.60)	1.12 (1.26)	1.58 (2.00)	1.41 (2.01)	1.64 (2.20)	1.41 (2.01)	5.25 (27.10)	6.54 (42.34)	3.58 (12.33)	3.29 (10.38)
Submergence tolerant variety	2.37 (5.16)	1.11 (1.25)	1.72 (2.46)	2.04 (3.70)	1.95 (3.33)	1.52 (1.83)	1.62 (2.13)	1.82 (2.83)	1.70 (2.40)	1.82 (2.83)	2.04 (3.70)	3.60 (12.52)	2.85 (7.67)	1.98 (3.43)
S.Ed CD (p=0.5)	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	1.60 3.21	0.20 0.87	0.36 0.73	0.10 0.44
Unweeded control	2.37 (5.16)	2.06 (4.26)	2.19 (4.33)	1.35 (1.83)	2.30 (4.83)	1.20 (1.46)	2.08 (3.83)	1.44 (2.10)	2.30 (4.83)	1.44 (2.10)	6.83 (46.25)	7.51 (55.92)	1.15 (0.83)	4.12 (16.52)
Twice Hand weeding	2.12 (4.00)	1.50 (2.26)	1.52 (1.83)	1.82 (3.33)	1.91 (3.16)	1.22 (1.50)	1.78 (2.67)	1.29 (1.67)	1.87 (3.00)	1.29 (1.67)	4.92 (23.75)	3.07 (8.93)	2.41 (5.33)	1.88 (3.05)
Butachlor @ 1.25 kg /ha	2.08 (3.83)	1.72 (2.48)	1.47 (1.67)	2.06 (4.25)	1.91 (3.16)	2.08 (4.33)	1.41 (1.50)	1.62 (2.13)	1.35 (1.33)	1.62 (2.13)	1.87 (3.00)	6.23 (38.41)	3.02 (8.67)	3.19 (9.68)
Bensulfuron methyl 0.06+Pretilachlor 0.6 kg ha^{-1}	1.95 (3.33)	0.89 (0.89)	1.95 (3.33)	0.91 (0.83)	1.47 (1.67)	0.71 (0.00)	1.35 (1.33)	1.31 (1.73)	1.22 (1.00)	1.31 (1.73)	1.22 (1.00)	2.07 (3.81)	2.97 (8.33)	1.26 (1.10)
Oxadiargyl @ 0.07kg /ha	1.82 (2.83)	2.06 (4.26)	1.82 (2.83)	1.82 (2.83)	1.58 (2.00)	1.41 (2.00)	1.22 (1.00)	1.41 (1.50)	1.35 (1.33)	1.41 (1.50)	1.87 (3.00)	5.52 (30.08)	2.48 (5.67)	2.16 (4.19)
S.Ed CD (p=0.5)	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.32 0.65	1.10 2.33	0.28 0.56	0.27 0.58

(Values in parenthesis are original values and those outside are square root transformations)

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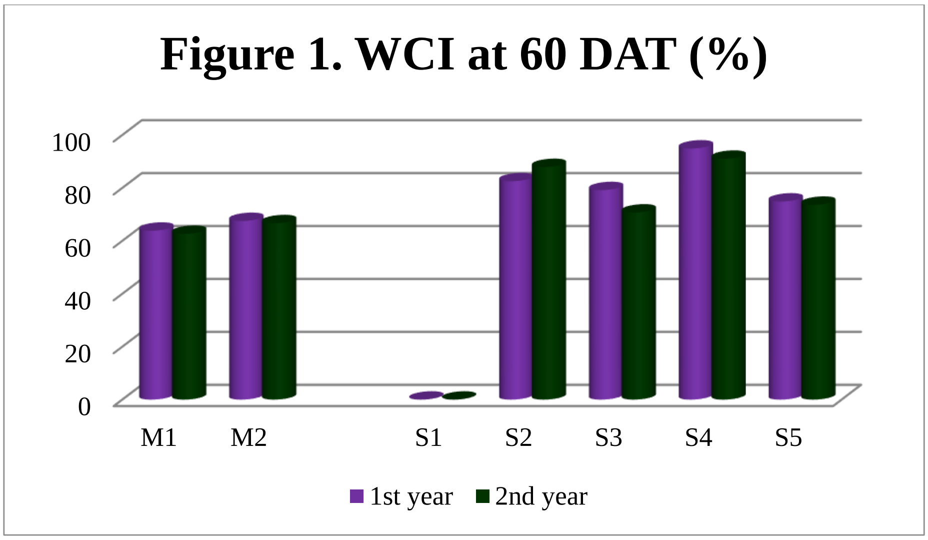

Table 2. Effect of treatment on rice yield

Treatments	Grain yield (t /ha)		Straw yield (t /ha)	
Main treatment	**1st Year**	**2nd Year**	**1st Year**	**2nd Year**
Conventional variety	2.32	2.88	4.15	4.19
Submergence tolerant variety	4.09	4.54	6.12	5.94
S.Ed	1.06	0.16	1.17	0.22
CD (p=0.5)	2.13	0.70	2.35	0.95
Sub treatment				
Unweeded control	2.8	2.80	4.60	4.25
Twice Hand weeding	3.51	4.27	5.37	5.65
Butachlor @ 1.25 kg /ha	3.00	3.50	5.01	4.96
Bensulfuron methyl 0.06+Pretilachlor0.6 kg ha^{-1}	3.58	4.26	5.55	5.53
Oxadiargyl @ 0.07kg /ha	3.10	3.73	5.15	5.18
S.Ed	0.04	0.06	0.24	0.08
CD (p=0.5)	0.08	0.12	0.5	0.18
Interaction				
S.Ed (MxS)	0.7	0.18	0.78	0.24
CD (p=0.5)	1.4	0.70	1.57	0.95
SEd (SxM)	0.02	0.08	0.25	0.12
CD (p=0.5)	0.04	0.18	0.5	0.26

Conclusion

The results indicated that submergence tolerance as a biological or genetic trait in crops helped suppressing invasive alien weeds like *Leptochloa chinensis* and *Marsileaquadrifolia*,

offering biotic resistance to invasion by alien weeds and when integrated with weed control measures were efficient in suppressing these alien weeds. Hence, weed control using submergence tolerant rice along with the application of bensulfuron-methyl 0.06 + pretilachlor 0.6 kg/ha could be suggested as an efficient weed control programme, for monsoon transplanted rice crop in Cauvery delta zones of tamilnadu.

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